Republic of the Philippines
Department of Public Works, Transportation and Communications
BUREAU OF PUBLIC HIGHWAYS
PILOT TECHNICAL ASSISTANCE PROJECT
MANILA

42

ACHIEVEMENT OF OPPORTUNITIES TO REDUCE CONSTRUCTION COSTS IN PUBLIC HIGHWAYS

REPORT OF THE AD-HOC GROUP

VOLUME I

APRIL 1973

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Department of Public Works, Transportation and Communications
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I SUMMARY

A. PURPOSE AND SCOPE

The construction of roads and highways in the Republic of the Philippines is currently a major activity in the infrastructure development sector. This emphasis is expected to continue into the future. Considering only the road and highway projects handled by the Bureau of Public Highways, the sums to be expended in the coming years will be considerable, about 30% of the total expenditure foreseen for all facets of the nation's development.

The expenditures will be made in the context of national planning policy, which is embodied in the current Philippine Four-Year Development Plan (1972-1975). Since the formulation of this Plan, one particular policy for its implementation has been given an increased emphasis. It is a greater utilization of labor-intensive methods in public works construction in order to create new opportunities for the employment of people. In addition, the potential of another implementation policy has become clear. If reductions in the costs of construction could be achieved, then the demand on the nation's resources to support the road and highway construction program could then be reduced correspondingly.

With such potential in mind, on 13 November 1972 the Department of Public Works, Transportation and Communications (DPWTC) formed an ad-hoc group from personnel in its Bureau of Public Highways (BPH) to begin work in a project of investigations aimed at identifying appropriate cost reduction opportunities. This group, identified as the Pilot Technical Assistance Project (PTAP), was provided the services of the consultant firm of Arthur D. Little, Inc. of Cambridge, Massachusetts, (ADL) by the United States Agency for International Development (USAID). The modus operandi of the PTAP was set forth in a published project statement, dated 15 November 1972.

The specific objectives adopted by the PTAP to guide the initial efforts of its work were:

- to identify the areas in road and highway construction on which its efforts should be concentrated;
- to select from such areas those that promise opportunities to reduce cost at the earliest time;
- for such cost-reduction opportunities, to recommend practical means for achieving them; and

- from the overall results of the work, to recommend whether further efforts should be undertaken in the future, the nature of these efforts, and the forms of organization that could be considered to take the responsibility for completing these efforts.

Thus the work of the PTAP has been envisioned as the first phase of a possible further effort. However, the contents of this report have been organized to be responsive to the objectives in the first phase of the PTAP.

The specific areas on which PTAP has concentrated its work of identifying cost-reduction opportunities are:

- the Projection of the Future Construction Program of the BPH;
- the Labor-Intensive Construction of Roads and Highways;
- the Prolongation of the Service-Life of Heavy Construction Equipment;
- an Improvement in the Distribution of Cement; and
- an Increase in the Utilization of Computers.

With respect to prolonging construction-equipment service-life, the PTAP narrowed the area for its concentration to two types of equipment which together account for the major portion of value of equipment in the mix for a road construction team. The reason was the need to reduce the scope of this topic to proportions which could be managed within the allotted time and with the staff available to the project.

B. METHODOLOGY

The PTAP adopted and followed a specific set of policies to guide its investigations. The set was selected to assure that the results could be implemented immediately in a manner responsive to the goals for economic progress which have been identified in the current National Development Plan. The policies have been:

- to undertake and complete the work program for the project as the initial effort of a longer-term effort, in which detailed analyses and evaluations that were not practical to cover in the first phase could be considered;
- to emphasize those features in the topics selected which can produce cost-reduction results of immediate usefulness;

- to avoid any overlap with the work areas delineated for the longer-term project of the Kampsax-Berger consortium (within whose period of scheduled activities the PTAP schedule fell), while at the same time taking advantage of the findings the consortium has already produced.
- to identify the immediately-useful cost-reduction opportunities sharply, so that the actions to achieve them are clear and enable decisions to implement them to be taken readily;
- to recognize that costs of construction involve not only the initial financial costs, but also the effect of the future costs which are associated with the maintenance of the completed facilities and which are incurred periodically during the life of the project; and
- to recognize that financial costs are interrelated with national economic costs, and that because of this interrelationship an opportunity to reduce a financial cost should take into account the implications of such a cost reduction on the national economic costs which arise from new opportunities to provide employment to people and/or to reduce demands for foreign exchange.

The PTAP began active work on 13 November 1972 and its investigations were formally completed on 30 March 1973. During this period, the work involved undertaking and managing a number of distinct stages of activities, which were the following:

- the definition of the prospective work topics in detail and the incorporation of changes in their purposes and/or scopes as the need for this became evident;
- the establishment and accomplishment of a number of vists to field offices of the BPH to secure data and information which required the compilation beforehand of a questionnaire covering the topics selected;
- the organization of the field work as a series of one-day conferences in the offices of the Regional Directors of the BPH, with the local engineering staff as the participants and with discussion in these conferences based on the questionnaire;
- the organization and accomplishment during 26-28 March 1973 of a three-day conference in Quezon City during which the findings in selected

topics were presented to a varied audience for discussion and argumentation; and

- the formulation of action plans from the overall results of the work.

C. FINDINGS AND CONCLUSIONS

1. The Future Road-Building Program and Its Implications

Projects already envisioned for the BPH, also information regarding the future availability of funds for road building, show the following forecast of the future road-building program for the BPH between FY 1973 and FY 1980.

Road Category	Total Accomplishment (Kilometers)	Estimated Expenditure (Millions of Pesos)
Paved		
Asphalt	5,033	836.6
Portland Cement Concrete	8,746	2,860.2
Unpaved		
Feeder	21,210	959.1
TOTAL	34,989	4,655.9

These eight-year totals may be compared with the four-year totals in the current Philippine National Development Plan, in which an expenditure of slightly over 2,000-million pesos is envisioned during the period FY 1972 through FY 1975. Therefore, the heavy emphasis in the present plan on road and highway construction (a 500-million peso annual average expenditure over 1972-1975) should continue through FY 1980 (a 580-million peso annual average expenditure over 1973-1980).

The forecast of the road and highway construction program shows that the large volume of road and highway construction can magnify the savings from a specific cost reduction opportunity even though at first glance the savings may appear prosaic.

The large volume of road-construction activity forecasted could represent a major means to provide the new jobs needed to occupy the increasing size of the country's labor force. Statistics from the 1970

census indicate that from 1970 to 1975 the size of the male population in the 20-49 age bracket will increase by about 1,120,000; distributed 360,000 in urban areas and 760,000 in the rural areas. These statistics also indicate that the corresponding increase between 1975 and 1980 will be even larger.

To support the road-building activity forecast, the lot of heavy construction equipment in the current BPH inventory may have to be multiplied three times. Specifically, for selected types of equipment, the following is apparent when current construction technology and service life expectations are basically unchanged:

	Present Inventory	FY 1973-FY 1980 Acquisitions
Crawler-Tractors		
120 HP	130	527
180 HP	451	1298
Dump Trucks		
4 cubic-yard	810	2985
6 cubic-yard	2100	6900

Therefore, if labor were to be substituted for equipment, and/or if equipment life were to be prolonged, a significant reduction in foreign exchange requirements over the period of the forecast could be achieved.

The road construction program forecast should consume over the period a total of 5.1-million metric tons of portland cement. This consumption will be distributed over the eleven regional areas of the BPH administrative organization. The consumption, distributed as an annual average over the 8-year period, represents about 9% of the current installed productive capacity of the Philippine cement industry, and about 18% of the current production of the industry.

2. Labor-Intensive Construction of Roads and Highways

a. Institutional Practices

The technology currently used by the BPH in the construction of roads and highways emphasizes largely capital-intensive technology, which requires a high input of foreign exchange and offers little

opportunity to employ labor on a large scale. The reason for this emphasis seems to be the combination of the effects of policies of international development-oriented lending institutions with the large influx of mechanical construction equipment to the Philippines after the liberation in 1945.

On the other hand, pre-war road-construction activities in the Philippines were labor-intensive. But because of the post-liberation shift to capital-intensive methods, very little of the pre-war experiences remains in the BPH. The senior staff who supervised the pre-war activities have largely retired. But, furthermore, even if their experiences were readily available, they may not be entirely applicable to the construction of present-day roads with the geometric and compaction specifications which are suited to modern vehicles.

The DPWTC seems to have recognized this lack. Recently, projects have been designated as "pilot" so that they can be organized to develop experience and to accumulate a body of financial-cost data. Two projects to reconstruct levees damaged by the 1972 floods have already been undertaken by labor-intensive means. A six-kilometer stretch of road between Capas and Botolan is scheduled for completion by labor-intensive technology in June 1973, but as of this writing work has not yet begun.

But for the meantime, the indications are that almost no capability exists in the BPH staff, or even within the DPWTC itself, to provide reliable financial-cost estimates of infrastructure projects which could be constructed by labor-intensive means. Nor does it appear that such a capability will be available early enough to permit the BPH to implement effectively the government policy to encourage labor-intensive construction.

The BPH will face two major problems in any serious attempt it makes to implement the government policy. They are:

- to know in advance the financial cost of construction of a given road by labor-intensive technology, and
- if the financial cost is higher than for construction by capital-intensive technology, to calculate the national economic cost

under each of the technologies under consideration, and then to adopt the technology that indicates the lowest national economic cost.

The solution to the first problem can begin with organizing the pilot construction of the six-kilometer stretch of the Capas-Botolan road in a manner that produces as comprehensive a compilation of data as practicable, which relate labor costs and labor productivity in the major unit operations of road building. The indications are that reliable and comprehensive data of these types will not be produced in this pilot construction project.

The solution to the second problem lies in establishing the justification for absorbing possibly higher financial costs, arising from the use of a labor-intensive technology. Labor-intensive methodologies that may result in increases in financial costs nevertheless may deserve to be adopted either because they operate to reduce national economic costs or because they carry additional national benefits. These two possibilities can be expressed as one possibility by referring to national economic costs per unit of benefits.

The procedure for assuring successful implementation of the government labor-intensive construction policy should incorporate the following elements:

- the recognition that certain government, or BPH, policies and procedures can serve to discourage the use of labor in road and highway construction. Examples of these are: the Contractor's License Law and the BPH prequalification requirements for prospective bidders which have equipment ownership and possession as one of the factors for licensing and prequalification; and the existing technical specifications for construction of roads and bridges which are capital-equipment oriented. Such policies or procedures can serve to obscure labor-employment opportunities which may be financially competitive and technically as acceptable as the equivalent capital machinery employment.
- the recognition of good examples of labor-intensive applications to projects such as those whose remote geographical location makes

it costly to move in equipment; those whose size is so small that financial costs of moving equipment to and from the site are extraordinarily high; and those incorporating excavation for drainage ditches, or culverts, in locations where considerable underground useful infrastructure is already installed.

- the recognition that opportunities for large-scale employment of labor in road construction requires that new social and economic benefits be generated because labor primarily has been employed in the construction. One method of assuring that such benefits will in fact be generated is to consider the construction of the road as the means to open and develop a new geographical area rather than as a project primarily to connect two population centers. Then, if higher financial costs have been incurred because a labor-intensive construction technology has been used, the justification to go ahead anyway will lie in recognizing that national economic costs may be reduced thereby.
- the recognition that conventional contracting procedures practiced by the BPH may have to be reconsidered because these procedures do not fit in with undertaking a major labor-intensive road construction project having broad social and economic considerations. As an example, the present ceiling of about two million pesos set for the construction of roads by administration (i.e., without the letting of a general contract) is too low for any labor-intensive road construction project longer than perhaps five kilometers.

b. Construction Technology

The construction of roads and highways by 100% content of labor, or by labor supplied with a nominal quantity of hand tools, is obviously impractical. Such an approach leads to extraordinarily slow rates of progress, non-compliance with specifications, and most likely an extraordinarily high financial cost. Accordingly, the intent of the government policy to encourage the employment of labor in road construction should be taken to mean a shift away from the capital content of current road construction technologies employed by the BPH and its contractors toward a lower capital content, with labor filling in the gap in the

technology thereby created.

The extent to which such shift should be made is not clear, nor can it become clear until there is a thorough analysis of the parameters affecting the appropriate size of the shift. For those instances in which the shift to a labor-intensive technology does in fact raise financial costs, the need is to choose the project design and the degree of labor-intensiveness in a manner that will minimize national economic cost per unit of benefits. The additional parameters that affect national economic costs and the generation of benefits then need also to be analyzed. Illustrations of some of the parameters involved in complete analyses are: the size of the labor force available to the project; the current employment distribution in that labor force; and the technical nature of, and the potential economy for, the terrain to be traversed.

An ideal procedure to determine the appropriate size of the shift for any given road construction project is as follows:

- identify the alternative technically-feasible technologies that may be considered to meet the two main objectives of the project (i.e., completion of the project to schedule and compliance with the construction specifications);
- for each alternative technology considered, analyze the parameters in order to produce the set of national economic costs that would be incurred to construct the project and the corresponding financial costs;
- select the appropriate construction technology for the project on the basis that the national economic costs will be the minimum when that technology is used;
- finally, determine the budgetary adjustments to be made internally within the government agencies affected, to accommodate an increase (if any) in the financial costs for the project which arise from the use of the appropriate technology. For example, savings in financial costs attributable to the reduction in unemployment because of the road construction project could be applied to help support the additional financial cost of the construction

project itself.

A minimum content of capital equipment must be incorporated in any construction technology that may be considered as one of the alternatives in the determination of the appropriate technology. This content is:

- the use of a powered mechanical compaction equipment to meet the specifications for compaction, and the use of motorized equipment for water transport and watering to the extent necessary to avoid loss of productivity from the equipment;
- the use of air compressors, pneumatic drills, and explosives for the removal of rock formations in order to meet construction schedules with the available labor force; and
- the use of motorized equipment for the transport of laborers to and from the site, when distances are excessive, to provide the maximum rest and relaxation periods for the laborers in order to encourage higher levels of productivity.

Furthermore, it is likely that the appropriate technology, when found, would contain a higher content of capital equipment than as just noted.

Therefore, ideally the first step in the construction of any major road project by labor-intensive means should be to identify the appropriate construction technology. This technology, when found, will have the following characteristics:

- it will represent the construction of the road project at the lowest national economic cost, as far as this cost can be reasonably determined;
- it need not be the same for every road construction project for which labor-intensive methods are to be encouraged;
- it may require a higher financial cost than has been experienced so far in the BPH from the technologies now employed;
- it will still represent a blend of capital equipment and labor, although it is likely that this blend will be labor intensive compared to the blend currently practiced in the Philippines; and

- its capital/labor content will depend on the state of the national economy and also on the state of the local economy in the area of influence of the road at the time the identification is made, and will change as the state of the economy changes.

But, it is not feasible to make such an identification unless an adequate compilation of data especially relating labor and equipment costs with labor and equipment productivities is available. As already noted above, the data for the labor aspects are lacking and will have to be especially compiled from road construction projects which the government has designated as "pilot" or "prototype".

c. Project Management Techniques

The project management techniques that would be employed in either labor-intensive or capital-intensive construction are both different and similar. For example:

- it is easier to predict the productivity of machines than it is to predict that of human labor;
- the productivity of capital equipment depends primarily on the mechanical condition of the machine, whereas the factors that influence the productivity of labor are far more complex. Some of these factors are: worker's physical condition and psychological attitude; conditions of employment, including incentives and amenities; and tools and working methods;
- on the other hand, the productivity of both equipment and labor depends on the planning and organization of the work and the quality of supervision of management;
- just as thoughtfulness in preparing the work plan can produce a maximum productivity from machines, similar thoughtfulness with respect to the work plan can produce high productivities from the labor.

The "paquiao" system, or the "takay" basis, which is the method historically employed in the Philippines for payment for accomplishment rather than for time spent on the job, contains many cultural and anthropological overtones which can lead to increased productivity. Although

its effectiveness has been demonstrated in the past, and its use wherever labor is a factor in construction is official DPWTC policy, nevertheless even in this system human factors are still present and these can act to prevent attainment of maximum productivity.

Therefore, an entire new discipline needs to be identified to relate the experiences of modern labor-management to historical labor practices in the Philippine cultural environment in a way which can help to assure that the performance of a large construction-labor force will involve a high level of motivation, and hence yield a high productivity. Otherwise, the use of a labor-intensive construction technology in the Philippines may become inefficient, the financial costs in such construction may then be found to be unjustifiably high, and hence not acceptable. Ultimately, the opportunity to utilize idle labor forces in the Philippines in the appropriate manner for infrastructure construction work will have been lost.

The personnel in the BPH (and also probably in the DPWTC) have not yet been exposed to such experience. Large-scale employment of labor in road construction would generate a need for such experience.

d. The Marikina-Infanta Road

About 100 kilometers of alignment of the proposed Marikina-Infanta road traverses public land and has not yet been committed for construction. This stretch of road represents an ideal candidate for construction as a prototype by labor intensive means for a number of reasons. These are:

- the public lands are probably available for resettlement by the workers engaged in the construction, and this can lead to now social and economic benefits not normally taken into account in a road feasibility study;
- the indications are that higher levels of unemployment exist in metropolitan Manila than is the case nationally;
- the road is close to Manila where the offices of the Bureau of Public Highways, government agencies, and university research groups, which would participate in different aspects of the project, are located;
- the metropolitan Manila area offers a large market for the new agricultural production from the lands opened by the road, and moreover

these products could have a higher value thereby allowing for smaller farm plots to be viable; and

- other potential benefits for this road have already been identified in a prefeasibility study recently issued.

Progress so far in implementing the government policy to encourage labor-intensive construction of roads seems to be slow. For example, the pilot project for the Capas-Botolan road already noted has been under consideration for about seven months and serious work has not yet started. It is likely that the project may have to be deferred until after the rainy season. Some of the problems that cause delay seem to involve difficulties in coordinating the efforts of the different agencies involved, or the efforts of persons who still have other commitments to fulfill.

To accomplish an effective prototype construction by labor-intensive methods for the Marikina-Infanta road, the need exists to establish a master plan for the road project, and to use such plan to direct the efforts of all government agencies that could be involved in its implementation. The plan should be designed to contain features which will maximize the national economic net benefits. One aspect is the choice of road alignment, which requires considerable advance thought in terms of the precise objective (or modification, when conflicting objectives are involved) to be achieved. The reason for this emphasis is the possible need to enlarge benefits relative to the national economic costs and to the financial costs. The two objectives which may be in conflict for the Marikina-Infanta road are:

- to provide the shortest feasible link between the two towns connected, which has the potential of minimum travel time; or
- to open as much as practical publicly-owned new land area for settlement and development.

3. Prolonging the Service Life of Heavy Construction Equipment

a. Incentives

It is clear that capital equipment will remain an important factor in the future construction activities of the BPH, and that prolonging the service life of equipment units now in the BPH inventory could offer an opportunity to reduce the financial costs of construction. The reasons are:

- Current government policies to encourage greater use of labor in road and highway construction, as moted above, do not obviate the need to employ substantial amounts of heavy capital equipment.
- The shift from the present construction technology to the appropriate construction technology will take some time to accomplish, which probably could be measured in years.
- Major capital expenditures will be required for new construction equipment to implement the future road building program presently facing the BPH, resulting from Government planning in this sector.

On the basis that current BPH equipment management practices remain substantially unchanged, total future equipment purchases can be estimated to be the following for the period between FY 1973 and FY 1980 inclusive:

Service Life (Operating Hours)	Purchases (US$)	Savings (US$)
10,000	187.9-million	-
20,000	97.7-million	90.2-million
30,000	65.5-million	122.4-million

Thus, the incentive to identify and attempt to change BPH equipment management practices that can extend service life is with little doubt a powerful one.

b. Current Efforts to Increase Service Life

Some changes to the equipment management practices of the BPH are currently in the process of implementation, and these can have the effect of increasing service life by overcoming ineffective maintenance practices of recent years. They result from the work of the Kampsax-Berger Consortium, and their implementation should be completed by 1 July 1973. The changes fall into two categories, which are:

- the establishment of regional mechanical depots and the area shops, which are to be properly equipped and organized for the necessary servicing of equipment and the training of operators and mechanics; and
- the institution in these shops of a comprehensive system of preventive

maintenance, designed to detect operating problems in the equipment and to provide for them in advance.

Two ineffective practices which have prevailed in recent years will not be eliminated by the changes. These are:

- Lack of standardization in the makes of the equipment units which have been imported. A pattern of demand for spare parts has resulted characterized by small requirements for many different part items. Such a pattern not only discourages local industry from investing and undertaking spare parts manufacture, but also complicates the management of parts inventories.
- Choice of makes of equipment whose manufacturers do not maintain adequate stocks of spare parts, or provide service facilities in the Philippines.

Some thought is currently being given to segregating different brands of the same type of equipment in specified geographical locations to simplify maintenance and spare part procurement problems. But, such a reallocation will require a significant expenditure for the one-time equipment transport that would be involved.

c. New Opportunities to Extend Service Life

Two specific technological non-destructive testing practices are available which, if introduced to the regional depots and to the area service shops, can serve to extend equipment service life. They are:

- the technique of analyzing periodically a sample of lubricating oil taken from a given equipment unit, to identify the trace elements present and their quantities; and then evaluating the accumulated data for that equipment unit to alert the repair shop to probable locations of deterioration, and at the same time to specify the urgency for attention; and
- techniques based on the use of radiation, ultrasonic, and electromagnetic analyses, and on the use of liquid-dye penetration phenomena, which can detect the extent to which metal fatigue failure has already occured in a given equipment unit so that the replacement needed can be identified and procured before major damage

from the failure of such parts occurs in the unit.

However, no use of either of these techniques is yet planned for the regional service depots.

Two specific administrative, or management, opportunities are available for consideration in terms of their effects on extending service life of construction equipment. They are:

- evaluating the relative merits between (1) providing the services of the operator with the equipment so that the operator feels an attachment to the machine, and a responsibility for its proper operation and the prevention of abuse, and (2) permitting the construction engineer to provide the operator on an ad-hoc basis so that the engineer can have control over the productivity of the equipment; and
- regardless of the source of the operator, establishing personnel policies that compensate the operators commensurate with his abilities, attitudes, and performance as well as providing for the security of his position, through offering opportunities for him to transfer to permanent staff when his performance justifies.

Local manufacture of spare parts can serve to extend equipment service life, not only because they would be readily available, but also because they could avoid equipment obsolescence when a foreign equipment manufacturer changes models and ceases spare part manufacture.

The Philippine manufacturing industry as now constituted seems to have the capability to manufacture most of the spare parts which are needed for heavy construction equipment. Recent surveys of the industry indicate that much of the parts-manufacturing capability required for construction equipment support exists today. The only lack seems to be local forging capability for crankshafts and bulldozer structural parts. Also, there could be problems to be solved in materials and dimensional quality control.

The Metals Industry Research and Development Centre (MIRDC) of the Board of Investments can be an important factor in developing the capability of the industry to supply a complete line of spare parts. The MIRDC already has such a program planned, although it is not yet funded. Also, the MIRDC is excellently equipped physically to undertake the quality

control aspects of such an industrial development program.

Since costs will be incurred in achieving longer service-life periods, which would have to be measured against savings in the reduction of new equipment purchases, the need exists for the BPH and its funding agencies in the Philippine government to adopt a rational method of determining when the service life of a given equipment unit has ended. The method should recognize certain factors which have apparently not been previously recognized in the past practice of determining service life, which as noted below is now under review. These are:

- the foreign exchange component of the maintenance costs for an equipment unit is a considerably smaller fraction of the total maintenance cost than is the foreign exchange component of the cost of new equipment replacement unit;
- the foreign exchange component of maintenance cost can be decreased further if more spare parts could be manufactured locally of satisfactory quality;
- locally available spare parts could extend service life through avoiding obsolescence because foreign manufacturers have ceased spare parts manufacture for a specific model;
- more intensive maintenance involves a labor-intensive technology, which is attractive because it has the advantage of offering the labor force the opportunity to raise the level of their skills and training; and
- more intensive maintenance of an equipment unit is technically feasible only when the user is satisfied with the productivity he is able to obtain from that equipment unit.

The criterion which has been followed by the Bureau of Public Highways up to recently is to repair equipment until a needed maintenance job costs 60 to 70% of the financial replacement cost of the unit. Presently, this guideline is under review as part of the work of the Kampsax-Berger consortium.

4. The Distribution of Cement

Two opportunities exist to reduce the cost of construction through

reduction in the cost of cement. One is a conversion of the cement handling operations of the BPH from the handling in bags to the handling in bulk. The other is through purchase of cement from decentralized factory depots either in bulk or in bags.

a. Bulk Handling

The BPH presently purchases cement almost entirely in bags. For the cement consumption anticipated through FY 1980, the total of the individual costs attributable to the use of bags is about ₱110-million, or about 22 percent of the value of the cement. The major cost item is the cost of the bags at about 63 percent of the total cost of handling in bags.

Not all of the cement consumption is amenable to bulk handling. In general, when cement-concrete is mixed in one or two bagger mixers, bagged cement is appropriate. Bulk cement is suited when cement concrete is mixed in central batching plants. Thus, all of the savings indicated above cannot be realized.

Some cement is already distributed in bulk, primarily in the greater Manila area. Interest exists currently in the cement manufacturing industry in the concept, but the financial problems the industry has been experiencing can prevent serious large-scale application.

From the point of view of the Bureau of Public Highways, a large-scale introduction of bulk handling of cement will cause two problems to arise. These are:

- the need to provide an opportunity for a Bureau of Public Highways personnel to become experienced in the technique; and
- the need to provide new investment to convert central cement-concrete batching equipment to accept bulk-cement (by installing additional silos in the batching plant, to purchase truck trailers designed for transporting bulk cement in tanks and provided with piping for unloading by compressed air, and to install devices in silos to loosen cement to make it flow more easily.

With respect to the method of pricing the supply of bulk cement, a need exists to analyze the savings from changing from bag handling to bulk handling in a manner that can allow the allocation of these savings in an

equitable manner among the participants. Thus, since the change involves the system of activities starting with cement in the storage silo in the factory and ending with cement being fed into the concrete mix, the gain should be allocated equitably among the cement manufacturer, the transporter, and the consumer.

b. Decentralization of Depots

It appears that significant reductions in the delivered cost of cement may be achieved by making better utilization of low-cost water transport when a major island in the country does not have a cement manufacturing plant, or when distances of transport by land on the same island are large. Achieving such reductions will require that:

- storage depots for bulk cement be located at selected market centers and be operated by the cement manufacturer as an extension to his factory;
- the depots be supplied constantly through water transport in barges programmed to make maximum use of the transport equipment;
- the cement be transported in bulk; and
- the depots be provided with bagging machines to accommodate the sales made in bags.

Some locations have been identified where depots operated as extensions to the cement factory can act to reduce cement costs. They are:

- Pasacao in Camarines Sur
- Legaspi City in Albay
- Bacolod City in Negros Occidental
- Zamboanga City in Zamboanga del Sur, and
- Tacloban City in Leyte

The scheme is technically feasible and would serve to reduce construction costs through reducing delivered cement prices, but it appears financially difficult for the cement industry at this time to undertake the investment necessary in new facilities. Therefore, the concept merits the attention of the Cement Industry Authority, which currently seems to

have the legal authority to act as the implementing agency.

5. Increasing the Utilization of Computers

a. Computer Facilities and Capability

The Bureau's IBM 1440 computer, used for accounting and data handling, is presently too small (8 K) in core size to process any Fortran program. Expansion to 12K or 16K would allow this, at a cost quoted by IBM in 1970 at about US$ 35,000. Other machines are locally available for rent, e.g., the IBM 360 at IBM/Makati for 1,000 pesos per hour, and the IBM 1130 at the Bureau of Telecommunication (BUTEL) for 150 pesos per hour (on weekends only), on which Fortran programs can be run until such time in the future that the Bureau's machine would be upgraded.

At least one BPH employee already has been writing Fortran programs and running them on a rental basis on the IBM 1130 at BUTEL, but there is a general unawareness of this capability and what it could mean to the Bureau. IBM/Makati periodically offers two-week training courses leading to capability in Fortran programming. These are free at IBM/Makati until January 1974. After that, there will be a fee involved.

The physical computer facilities available to the BPH are adequate for its foreseable needs. Expansion of the BPH IBM 1440 to 16K size (the size needed in order to handle Fortran programming) is not justified at the present time. Instead, rental time as necessary on external computer facilities should be satisfactory. When rental costs exceed, say 1,000 pesos per week, expansion could probably be justified. Then almost all program applications of interest to the Bureau could be run within the Bureau's own facility.

b. Development of a Pavement Evaluator

A pavement-evaluator computer program in the Fortran language, for comparing the initial and continuing costs for various alternative road and highway pavements, has been demonstrated successfully on the IBM/Makati computer. The demonstration was based on an example containing many assumptions for each pavement type considered, especially with respect to road maintenance costs, local labor component, and the foreign component of initial pavement installation costs.

Results on such a basis showed the total (global) costs were comparable

for asphalt concrete pavement at low discount rates; but at higher discount rates the total cost was favorable for the pavement with the lower initial cost (asphalt, in this example). But the results have value only for illustrational purposes.

There is a lack of reliable data with which to supply the program, and this lack is sufficiently widespread to make the results calculated by the program unrealistic for decision making. There are clear needs for the compilation of data regarding:

- costs to maintain roads actually experienced rather than costs equivalent to annual allowances arbitrarily given the BPH highway districts (on which the present evaluator is based);
- the allocation of the different items of cost for the initial installation of the pavement to foreign exchange and to local labor.

c. Other Applications

Data collection for use in the planning of the labor-intensive construction of roads and highways and for prolonging the service life of heavy construction equipment will require convenient use of high speed data processing facilities.

The Bureau of Public Highways Computer Center is focussing its attention on matters largely of an accounting or inventory control nature. The personnel have the capability to undertake work of a technical nature despite of the lack of capability of the IBM 1440 installation to accept a Fortran compiler. To illustrate, the personnel rewrote the pavement-evaluator program from its Fortran version to a machine-oriented language and ran it successfully, i.e., they produced the same output results for the input data used in the development of the Fortran version pavement evaluator.

6. Nature of the Cost-Reduction Opportunities

Labor-Intensive Construction Through the multiplier effect of wages paid and the corresponding reduction in the use of imported construction equipment, the cost-reduction opportunity here is basically the reduction in the national economic cost of a road construction program. The financial costs may rise, although this is not necessarily so and possibly could be avoided by careful implementation of any plan of action designed to achieve

labor intensiveness. In any event, the application of labor-intensive construction to roads and highway requires a close and effective coordination among the agencies of the government concerned with economic planning, budget allocations, and road and highway construction.

Equipment Service Life The extension of service life of heavy construction equipment should have the effect of reducing simultaneously the national economic cost, the foreign exchange cost, and the financial cost of the use of the equipment. Local employment opportunities for skilled labor (mechanics) will increase, especially if a greater demand for spare parts leads to local manufacture on a wider scale.

Distribution of Cement The improved distribution of cement offers an opportunity to reduce financial costs in the Bureau of Public Highways road building activities. The investment to improve cement distribution will be capital intensive, and this may have the effect of increasing the corresponding national economic costs. However, the longer-term social benefits of eliminating the unrewarding, repetitive manual labor involved in handling cement and absorbing the displaced labor into the labor-intensive construction activities should justify any national economic cost increase by making it temporary in nature.

Use of Computers The work load of engineering personnel in the Bureau of Public Highways need not be affected by intensive computer use because appropriate use of such a facility will enable the personnel to explore alternatives in the design procedures, and to handle the large masses of data that will arise, as already noted, for which there is no realistic alternative. The ability to choose among alternatives allows criteria to be adopted which aim to reduce, where practical, all three costs simultaneously.

D. ACTION PLANS

The PTAP recommendations incorporate detailed plans of action based on the findings in each of the four topics of investigation now presented.

1. Labor-Intensive Construction of Roads and Highways

The PTAP recommends that:

- immediate opportunities to increase labor employment in road construction be identified in those areas of the conventional technology where

the use of manual labor can be substituted for the use of machinery at competitive financial cost;

- the portion of the proposed Marikina-Infanta road not yet committed for construction be established as the prototype for the appropriate application of the large-scale employment of labor in road construction,
- a master plan be established to guide all activities of government agencies which would be engaged in the implementation of the two recommendations above.
- the master plan provide for the incorporation of specific procedures and activities coordinated as an action plan.

First Set of Activities

The objective of the first set of activities is to identify, as far as practicable, quantitative opportunities for immediate labor substitution based on:

- a compilation of the experiences from the labor-intensive construction of the six-kilometer stretch of the Capas-Botalan road in a form such that it can have maximum utility for financial-cost and national economic cost estimating work;
- an analysis of the work tasks defined in the detailed construction drawings prepared by the Bureau of Public Highways for the stretches of the Marikina-Infanta road that are now committed for construction in a conventional manner, which is to include physical observation of work in progress; and
- the identification of the changes to the Bureau of Public Highways contracting procedures, necessary to remove impediments to realizing those opportunities for using labor more intensively that can be justified by competitive financial costs.

The final action for the first set of activities in the action plan is to be the dissemination of the results throughout the Bureau of Public Highways district, city, and regional offices, together with recommendations for their implementation.

Second Set of Activities

The second set of activities is to be undertaken with several objectives as follows:

- the demonstration that the construction of the prototype Marikina-Infanta road is technically feasible by labor-intensive methods;
- the demonstration that the construction of the road by labor-intensive methods is economically feasible in terms of national economic costs;
- the demonstration that a schedule for the completion of the project can be established in advance with reasonable expectations that it will be met; and
- the demonstration that the quality of the construction will be equivalent to the quality expected in current construction projects involving similar terrains and environments.

Achieving these objectives is to involve also achieving a number of interim objectives. These are the following:

- the compilation of comprehensive knowledge of the resources of the area traversed by the prototype road, especially those which were identified in the prefeasibility study of the PES, for further investigation in relation to the road construction;
- the compilation of comprehensive knowledge of the labor resource available for the construction program;
- the compilation of a body of sociologically-oriented knowledge about the Philippine laborer and of modern techniques for labor management aimed at identifying candidate methods to increase his motivation;
- the identification of the labor-intensive technologies that may be appropriate for the construction of the road in terms of achieving the construction at minimum economic cost;
- the estimation of both the national economic costs and the financial costs for the construction of the road if conventional capital-intensive technology were to be employed and when the appropriate technology is employed;

- a comprehensive description of the area development to be realized as a result of the construction of the road and its capability to absorb the labor force, and others, as permanent settlers; and
- the estimate of the amount and the schedule of the employment that can be offered, both when the appropriate technology and if the conventional technology were to be employed in the road construction.

In order to achieve the overall and the interim objectives, at least the following specific work tasks are to be undertaken:

- compilation of experiences in other countries where roads of similar scope as the Marikina-Infanta project have been constructed using labor-intensive methods (such an experience seems to be available in Taiwan in connection with the construction by 10,000 laborers of a 300-kilometer network during 1957-1960, now known as the East-West Cross-Island Highway);
- the formulation of the project management plan which anticipates the problems to be solved related to managing and supporting large numbers of men in a work force laboring over a number of years, including the problems of maintaining their motivation, their efficiency, and the required construction progress;
- definition of the non-road construction activities that must be incorporated in the master plan in order to generate the new social and economic benefits. (Examples are: construction of viable agricultural land; community development incorporating health and educational services; financial services e.g., a special bank, particularly during the early stages of settlement in new agricultural land, development of mineral resources; and the development of industry);
- incorporating in the designs dealing with the earthmoving operations (particularly in the mountainous areas) the prospects for cont[illegible] leveling the land adjacent to the road to provide additional areas for agricultural purposes;
- giving consideration to the feasibility of incorporating such techniques for stimulating and raising motivation levels in the labor force as:

  (a) educating the workers to a clear understanding of the

social and financial aspects of the road project,

(b) providing a level of savings acceptable to the workers such that they will have working capital should they eventually settle in the land opened by the road,

(c) providing feeding and food items on the job to assure adequate levels of nutrition, aside from this use as compensation for the work, and

(d) the educational and training needs to be incorporated in the support services to the work force to prepare the workers for the problems of resettlement, or to train them in skills and crafts for future employment.

- establishment of a plan for recruiting the labor force which will consider the feasibility of recruiting from squatter settlements in the metropolitan Manila area, as well as from other sources;
- establishment of a plan for discharging the work force as required to take advantage of settlement opportunities as they arise.

As the final action for the second set of activities, the intermediate and final results, as they become available, are to be organized and evaluated as a series of written guides for the selection and implementation of road projects throughout the country which may then be found appropriate to construction by labor-intensive methods.

Organization

The satisfactory accomplishment of the two sets of activities is to be made the responsibility of a task force. This task force is to have the following character

- all members are to serve full time, and to have no assignment carried over from their regular employment;
- capability in all disciplines necessary to accomplish the professional content of the work is to be represented in the full-time staff;
- separate and independent office support is to be provided;
- careful consideration is to be given to the experience, qualifications,

motivation, and general capability of the person designated to lead and direct the task force; and

- the task-force leader is to be responsible to, and receive policy direction from, the Cabinet Coordinating Council for Labor-Intensive Operations.

The task force is to remain in existence until all its responsibilities have been discharged.

With respect to the delegation of authority to the task force, the following authority delegation seems to be the minimum to permit the force to act efficiently and to conform to its schedule:

- be authorized to take over the responsibility for the data monitoring and gathering operations of the pilot project to construct the first six-kilometers of the Capas-Botolan road by labor-intensive methods;
- be enabled to control the expenditure of its funds in a manner that clearly will not hinder or delay its progress;
- be given upon application, funds to continue its operations at periodic intervals upon the submission of the estimate, and the submission of a report of its financial operations during the previous period; and
- be authorized to contract with local Philippine firms, organizations, and institutions qualified to undertake investigations to preagreed-upon terms of reference.

Immediate Task

As its immediate task upon creation, the Task Force is to formulate and submit to the Cabinet Coordinating Council the overall work program covering its entire responsibility together with the schedule for its completion and an overall estimate of its cost. The work program is to be divided into stages, or phases; and a detailed work program, schedule, and cost estimate is to be submitted for the first stage. Particular emphasis is to be placed in the work program for the first stage on the immediate take-over of the data accumulation and evaluation aspects of the Capas-Botolan pilot project.

2. Prolonging the Service-Life of Heavy Equipment

The PTAP recommends that:

- efforts begin now to formulate and implement additional changes in the operations of the preventive maintenance program now being introduced to the new regional depots, area shops and mobile shops;
- the additional changes be geared to reduce the costs of the operation of the preventive maintenance program and to increase its effectiveness in prolonging equipment service life;
- initially, attention continue to focus on the two equipment types so far considered, namely: 120 and 180 HP tractor-crawlers and 4 and 6 cubic yard dump trucks; and
- later, as the initial task of implementing the recommendations eases, efforts be undertaken to (a) bring in other equipment types in the BPH inventory for similar treatment, and (b) bring in other equipment-owning agencies of the national or local governments who may be interested in applying the results to their own operations.

The PTAP recommends further that four separate action plans be adopted in order to implement the recommendations.

Determination of Service Life (Action Plan No. 1) The objective of this Plan is to establish a rational method

- for use within the Mechanical Service Division of the BPH, to enable it to determine when to recommend that a given equipment unit should be disposed because its service life has reached its end; and
- for use within the planning and funding agencies of the Department of Public Works, Transportation, and Communications and of the Government, to enable them to determine whether or not a replacement unit is warranted from the broader point of view of government budgeting demands and knowledge of the forthcoming road construction program.

The method eventually selected is to operate as follows:

- all financial cost records and all technical details of preventive and other maintenance work performed on any equipment unit of the two types considered are to be supplied by the area to the regional shops,

and thence to the central office of the Mechanical Services Division;

- the data in the records are to be processed during each interval of equipment operation (for example, after each 2000 hours of operation) to calculate the appropriate financial cost function during that period, in order to compare it with the criterion adopted in the method for measuring the end of the service life;
- when the criterion suggests that the service life of a particular equipment unit has ended, the Mechanical Service Division is to recommend its replacement to the BPH management who, in turn, is to determine whether the needs of the current construction program warrant the replacement;
- when the BPH determines that a replacement is warranted, it is to recommend the replacement in the budget plans for the forthcoming fiscal year, by forwarding in its budget request the complete details of the financial-cost analysis and breakdowns of costs into those paid in local currency, those paid in foreign exchange, and those paid for the employment of labor;
- the budget planners are then to decide from the national economic costs of the current maintenance on the particular equipment unit, measured against the national economic cost of the replacement of the unit, whether (a) to approve the replacement, or (b) to defer consideration of replacement until the request is raised again with the submission of new data, for example, after the next interval of operation;
- in the event the decision is in favor of (b) not to replace, appropriate adjustments are to be made in the budget for the BPH in order to accommodate the higher financial cost of maintaining that particular equipment unit during the next interval of operation; and
- if the decision is (a) to replace, the purchasing procedure is to take account of the accumulated cost experiences from the unit being replaced in order to secure the replacement, i.e., to use the experiences in weighting one brand of equipment against another during the procurement.

A technical description of one method which can enable the functions

described above to be achieved is contained in Section V of the Report.

Transfer of Testing Technology (Action Plan No. 2) The objective of this Plan is to transfer appropriate non-destructive testing technology, available in advanced industrial nations, for use in the regional mechanical service depots of the BPH as an aid to achieving a less costly and more-effective preventive maintenance program.

The elements to be incorporated in the Plan are to be the following:

- the identification of the technologies which can fit into the operations of the regional depots, the area shops and the mobile shops;
- the identification of the methods for operation and the training needed by the personnel involved in the operations;
- for each method selected, an assessment of the potential to reduce the cost of preventive maintenance practices in the various repair shops; and
- for each method identified, an estimate of the cost of its installation and operation.

Personnel Motivation (Action Plan No. 3) The objective of this Plan is to review the personnel practices in the Bureau of Public Highways, related to the operation and maintenance of its equipment in order to identify those changes which can serve to motivate (a) the operators to take conscientious and competent care of the equipment during its operation and (b) the mechanics to perform conscientious and competent maintenance work.

The elements to be considered in the review are to include the following:

- wage and salary scales including the benefits conventionally paid in the public and private sectors of the country;
- relating a particular operator to a particular equipment unit to generate a pride in the operator from effective operation and avoidance of abuse; and
- providing more intensive on-the-job training than is presently envisioned, which can lead to promotion to positions of increased responsibility.

Local Spare Parts Manufacture (Action Plan No. 4) The objective of this Plan is to provide a basis for the Bureau of Public Highways to cooperate with the

Board of Investments in the desire of the latter to encourage greater local manufacture of spare parts through employing the efforts of the Metals Industry Research and Development Centre (MIRDC).

The cooperation is to incorporate the following elements:

- compile from the BPH maintenance records the spare parts items that are consumed, their delivered cost, the details of their design, the specifications for the materials of fabrication, and the dimensional tolerances; and compile these in a manner that both describes the market offered to local manufacturers by the BPH and describes the technical requirements of the parts to the MIRDC;
- explore the feasibility of modifying component designs without detriment to the operation of the machines, to enable local manufacture instead of import (for example, by the use of an alternative design of diesel-engine turbocharger to that of the original equipment manufacturer);
- formulate a purchasing policy for locally-manufactured spare parts, whenever these are offered, which does not (a) burden the manufacturer with extraordinary working-capital problems because payments may be delayed, and (b) burden the BPH with spare parts of inadequate quality with respect to the materials of fabrication, the design, and the dimensional tolerances; and
- identify the role of the MIRDC in the control of the quality of locally-manufactured spare parts.

Organization

In view of the transitory situation currently prevailing in the Bureau of Public Highways with respect to reorganization, the PTAP is not now in the position to recommend regarding the implementation agencies for the four plans.

3. The Distribution of Cement

The PTAP recommends that

- the Bureau of Public Highways provide opportunities for its personnel to become experienced in the large-scale handling of cement in bulk by selecting specific road construction projects, supplying them with bulk cement, and permitting them to serve as pilot projects;

- the Bureau of Public Highways call the attention, through official channels, of the Cement Industry Authority to the findings and recommendations that are relevant to the decentralization of factory depots; and
- the Bureau of Public Highways encourage actions by the Cement Industry Authority toward such an end by cooperating with the implementation efforts undertaken by the Cement Industry Authority as far as the Bureau's interests are affected.

Only one action plan needs to be adopted with respect to these recommendations. Accordingly, the PTAP recommends further the adoption of an action plan to deal with conversion to bulk handling from cement factory to road construction projects in which portland-cement concrete is prepared in centralized batching plants. The Plan is to have the following character:

- the efforts are to be recognized as a pilot operation in which the accumulation of data and experience is one important objective;
- key BPH personnel are to be given opportunity to study the problems and observe the solutions as they become evident in the pilot projects;
- the Construction Division of the BPH is to be given the responsibility and the necessary funds for the implementation; and
- the results are to be evaluated and recommendations formulated so that a detailed plan becomes available to guide the BPH in the use of bulk handling of cement for cost savings in future road construction programs.

A list of candidates from which the pilot projects may be chosen is the following:

- Batangas City-Lobo Road, Batangas City section, which will serve primarily the Fortune Cement Company which must use this road for access to all its markets. The PTAP understands that the cement plant management has already offered to assist in the construction of this road by supplying cement-concrete components free of cost. The company already has the bulk carriers, and also needs the road for evacuation of its output. This project can offer the BPH the opportunity to implement conversion to bulk handling at low investment;
- the Layac-Mariveles Superhighway (Layac-Balanga Section) now under

construction by the Construction and Development Corporation of the Philippines;

- Digos-Cotabato Road in Region XI which is now under construction with Philippine Rock Products Inc. as general contractor. The cement source for this road is the Bacnotan plant north of Davao City. Philrock has already used the bulk-transport method in the Greater Manila Area;
- General Santos-Cotabato City road in Region XI which is now in the stage of contract negotiation; and
- Iligan City-Cagayan de Oro-Butuan City road which is now in the detailed design stage. The cement sources for this road are the two plants in Iligan City, and one in Misamis Oriental. One of these companies is already interested in the bulk handling concept.

4. The Greater Utilization of Computers

The PTAP recommends that the Bureau of Public Highways

- marshal its forces to provide the capability to undertake computer processing of the data which will arise during the implementation of the Action Plans;
- continue the work to develop the pavement-evaluator further with the objective of achieving a level of reliability from its use acceptable to the Bureau's road design personnel; and
- use its assets of trained personnel to develop additional usage for the computer facilities it owns, or has access to.

The PTAP recommends further that two action plans be adopted in order to implement the recommendations.

Pavement Evaluator Program (Action Plan No. 1) The objective of the Plan is to improve the accuracy and sophistication of the pavement-evaluator program through a continual data collection and compilation of road maintenance experiences beyond that which is currently being undertaken. The work is to incorporate the following elements:

- quantification of the BPH actual maintenance experience (costs) with various pavements as a function of traffic density and weather, and the allocation for several new projects with different pavement

designs, of the foreign exchange and local labor component; and

- the review in terms of relying on its results, of the sophistication of the present pavement-evaluator program when reliable data has been accumulated, to determine whether other parameters should be incorporated, such as weather conditions and traffic patterns.

The primary responsibility for the data collection work is to be given to the Maintenance Division of the Bureau of Public Highways, which is to be provided the assistance of the Computer Center with respect to the technical details of computer programming.

Additional Usages (Action Plan No. 2) The objective of the Plan is to identify and implement additional opportunities to employ the computer in the technical activities of the Bureau. The work and organization is to incorporate the following features:

- appointing a small task force to list and categorize the major calculation activities within the BPH, and to identify individuals who have already had, or who might profit from, computer training;
- carefully selecting and sending the order of a dozen of its engineering personnel to IBM/Makati's periodic two-week training courses;
- carefully selecting a few areas in which increased use of the computer should be encouraged;
- including as one of the priority areas, the computer work foreseen in the implementation of the Action Plans recommended;
- arranging rental contracts with whichever of the externally available computers is cheaper at the time, to allow BPH personnel to run the programs that they may subsequently develop during the course of their work;
- upgrading the Bureau's IBM 1440 when the external Fortran-run rentals routinely exceed the order of, say 1000 pesos per week, or when other data processing loads at the Bureau dictate expansion of the machine to 12K or 16K size; and
- publicizing within the BPH the programming capabilities that may already exist, or which subsequently will be developed within the Bureau.

II. INTRODUCTION

Public works construction in developing countries is usually the major activity in the infrastructure sector, and thus this activity represents a major consumer of the resources of the country, which characteristically are in short supply. Accordingly, any change in methods which serves to reduce infrastructure construction costs will also serve to reduce the demand on the supply of resources, or conversely, such a change will permit a given quantity of the resources to produce additional construction.

The current planning by the Philippine government in the infrastructure sector puts a major emphasis on the construction of roads and highways. Thus, the present National Development Plan specifies that, of every 100 pesos to be invested in the development of the country during the four-year period, 1972 through 1975, about 30 pesos will be invested in the construction of roads and highways. The total of investment in road and highway construction has been estimated in the Plan as a little over 2,000-million pesos, of which 25%, or 500-million pesos, will be used to buy foreign exchange. As will be noted later in this report, newer estimates by the PTAP, but this time for the eight year period 1973 through 1980 - i.e., double the plan period - indicates expenditures of about 4,600-million pesos for road and highway construction.

A. ORIGINS OF THE PROJECT

The project resulted from an interest by the Philippine government, acting through the Department of Public Works, Transportation and Communications (DPWTC), in the potential to reduce costs in the construction of public works. This interest coincided with a similar interest in this potential by the United States Agency for International Development (USAID).

On May 1972, the DPWTC agreed with USAID to undertake a joint project focused on the construction of roads and highways. The Bureau of Public Highways (BPH) became the responsible agency of the Department, while AID delegated its participation in the project to the firm of Arthur D. Little Inc., of Cambridge, Massachusetts (ADL). Preliminary work began in July 1972, aimed at the selection of the topics for investigation and the organization within the BPH of an ad-hoc staff. Active work began on 13 November 1972 as the Pilot Technical Assistance Project (PTAP).

B. SELECTION OF THE TOPICS

The PTAP selected the following topics. The first three represent the original selection, while the fourth is an outgrowth of early work in the cement topic.

- The Labor-Intensive Construction of Roads and Highways.
- The Prolongation of the Service Life of Heavy Construction Equipment.
- The Improvement of the Distribution of Cement.
- An Increase in the Utilization of Computers.

Moreover, to provide a base for the quantitative assessment of cost reductions, the PTAP expended significant effort to project the future construction program of the BPH through the fiscal year (FY) 1980.

The PTAP considered specific criteria in the process of selecting the topics. These were:

- Responsiveness. The topic should recognize government policies as expressed in the current Plan for National Development. The most significant of these policies is the encouragement of the more intensive use of labor in construction activities.
- Scope. The topics should be sufficiently narrow in scope so that significant findings can result from the combination of the personnel resources used and the time available to be spent for completing the project work.
- Implementation. The recommendations should be practical in content, so that immediate implementation can be considered within the context of existing institutions.
- Aspects for Emphasis. Primary emphasis in the work should be placed on materials usage and on the construction technology employed, although management problems of sufficiently narrow scope need not be excluded.

C. CONCEPTS OF COST REDUCTION.

The reduction of the cost to accomplish a given task is, of course, always desirable. But more than one concept of cost needs to be considered as ways to reduce cost are being studied. Three distinct concepts of cost

are relevant in the present context. These are:

- financial or market costs, which are costs as usually conceived by the BPH, its contractors, or by an equipment owner;
- foreign exchange costs, which pertain to payments for imported goods and services (and, less obviously, to costs represented by reductions in the foreign-exchange receipts of the country arising for any reason); and
- national economic costs.

National economic costs can differ from (and are usually lower than) ordinary financial costs for two principal reasons. One reason is that financial costs, such as taxes, are not really costs when viewed from a national standpoint. Taxes are essentially transfer payments. The other reason refers to the use of shadow prices in the calculation of national economic costs. Table 1 contains some useful definitions of the terms used in this discussion.

The national economic costs of a construction project are typically the values of the goods and services that can no longer be produced, because the resources needed for such production have been shifted (re-allocated) to the construction project. Such national economic costs are ordinarily lower than the money (financial) payments to secure the resources for the construction project. In order to calculate the national economic costs of any particular method of accomplishing a given task, in the course of completing the construction project, the analyst needs to use the shadow price (rather than the market price) of each resource to be consumed in completing the task. These shadow prices will need to have been developed for current economic conditions in the Philippines, and as well when changes in these conditions occur, by an organization such as the National Economic Development Authority (NEDA).

As indicated in the list of definitions in Table 1, shadow prices can provide a truer indication of the supply of (and demand for) any resource or any good or service, than could market prices provide. Whenever shadow prices differ significantly from market prices, there should be a calculation of financial costs using market prices, and of national economic costs using shadow prices, if an objective evaluation of a cost-reduction opportunity is to be practical. Objectivity, in the evaluations will be important,

TABLE 1

SOME USEFUL DEFINITIONS

COST

The word "cost" connotes the need to give up, or to forego something, that is valuable. A cost is incurred, ordinarily, in order to obtain a benefit which the cost-incurring party expects will be more valuable to him than whatever he is giving up. Most times a private party or a government agency incurs a cost as part of a transaction with an outsider; in other words, the party turns over something of value (the cost item) to another party and receives in exchange an item of value (the benefit).

But cost need not take place through such a transaction. If a farmer shifts a parcel of land that had been used for rice, to the production of sugar, the cost of obtaining the benefit (sugar) is the rice that can no longer be produced by the parcel. Similarly, if a nation shifts a body of workers from farm work into the construction of a highway, the cost of the highway is the value of the farm output that can no longer be produced. Thus, part of the cost of the highway is the crops that must be sacrificed or foregone by this alternative use of labor.

FINANCIAL (OR MARKET) COSTS

These are costs as seen from the point of view of the investor in a construction project, or the investor in (or owner of) an item of capital equipment. Such costs include operating and maintenance expenses, taxes paid, interest payments, and depreciation.

NATIONAL ECONOMIC COSTS

These are costs as seen from the point of view of the nation which is committing its resources in order to construct useful works or own needed capital equipment. Such costs do not include the payment of taxes because taxes are merely a transfer of funds from one part of the nation to another part (the government). If prevailing market prices do not accurately indicate the scarcity and the productivity of the resources covered by the costs, national economic costs must be calculated using "shadow"prices (see below) rather than market prices.

SHADOW PRICE

This is a price that is a more accurate indicator of the supply and demand situation for a particular good or service than is the market price. The shadow price of an input is typically equal to the opportunity cost (see below) of that input. Shadow prices are used in calculating the national economic costs (and benefits) of a project. For example, shadow prices with respect to the national economic costs of labor are "shadow wages", which reflect the true picture of the supply and demand for labor as compared with wages paid by an employer.

OPPORTUNITY COST

This is the cost to the nation of shifting a given resource, such as labor, away from its present function in the economy. Such a shift means that the output now being produced by the resource must be sacrificed, or foregone. Thus, the "opportunity" to use that resource to produce that output is lost. Generally, the value to be produced by a resource in to its new allocation is the benefit that is to be compared with the cost that is the value sacrificed, because of the shift — that is, the opportunity cost.

MULTIPLIER

This is the name given to a process by which the volume of additional national income (see below) generated by a project (such as a new investment) is made greater than the income produced internally within the project. The process involves the repeated re-spending of the money incomes created inside the project, each re-spending prompting the creation of additional national income. The value of the multiplier is the ratio of the total increment to national income attributable to the project to the increment to income produced inside the project. The formula for the multiplier is $\frac{1}{1-c}$, where "c" is the typical fraction of any income increment that is re-spent at any time.

NATIONAL INCOME

This is the total value of all the goods and services produced by the residents of a nation (or by lands and other assets owned by the residents) over a given period of time, usually one year. National income may be thought of (and can be measured) as the sum of all the wages, rents, interest, and profits earned by these residents. To compare the national income of one year with that of another, it is typically desirable to eliminate the effects of price level changes; then one is in a position to compare real incomes.

particularly with respect to the topics concerned with labor-intensive construction and the prolongation of equipment service life.

The use of shadow prices, and thus of national economic costs, in costing public works construction in the Philippines can have two important consequences in establishing the justification to implement a cost reduction opportunity:

- first, since for a given project national economic costs are ordinarily lower than financial costs using any given set of construction methods, projects that might be rejected if evaluated in terms of financial costs alone may be found to be desirable in terms of national economic costs; and
- second, if various construction methods, varying in the degree of labor or capital-intensiveness, are considered for a given project, the least national-economic-cost method is likely to be more labor intensive than the least financial-cost method.

The reasons for the first consequence(national economic costs lower than financial costs) are evident from shadow price relationships, and from a unique feature of taxes. Shadow wages are lower than market wages. This difference is traceable to the fact that shadow wages, which indicate what labor is presently earning, are pulled down by unemployment and underemployment. Net taxes (taxes minus any subsidies) are a financial cost. They are not a national economic cost, because the payment of taxes constitute merely a transfer of funds from taxpayer to the government; thus, taxes do not involve the use of real national resources.

The reason for the second consequence (the use of shadow prices implies more labor-intensive methods) is that (a) the shadow price of labor is lower than the market price, and (b) the shadow price of foreign exchange is usually above the market price. The latter means that capital equipment, which must be brought with foreign exchange, is more expensive in terms of national economic costs than in terms of financial cost.Furthermore,if the cost of the equipment must be paid to foreigners any more rapidly than the equipment is productively used, there is an additional "opportunity" interest cost, which is estimated to approximate 15% in the Philippines. *

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* Updated Feasibility and Preliminary Engineering Report Tarlac-Sta. Rosa Road, August 1972, Norconsult A.S.

Unfortunately, there may be instances in which the reduction of costs using one concept entails an increase in costs using a different cost concept. For example, a reduction in national economic costs (and in foreign exchange costs) by the adoption of a labor-intensive method may operate to increase financial costs. Any such instance may call for a policy decision by the Government. We should only point out that national economic cost is a more fundamental concept, and that it will be in the national economic interest to concentrate on the reduction of national economic costs if some way can be found to handle any higher financial costs that must be covered.

Some of the possibilities that have been studied promise not merely to reduce costs but also to increase national economic benefits. Example of such benefits include the redistribution of income effects as well as the morale and training benefits that may be associated with the higher employment made possible by labor-intensive techniques. Another type of benefit would be the enlargement of the national income made possible as a new highway opens areas for settlement with consequent additions to the value of production. All of these possibilities may be brought formally within the context of cost reduction by introducing a fourth concept of cost--a concept of a different order from the others--the concept of reduced national economic cost per unit of national economic benefit. Thus, any modification of the design of a project which adds more to gross benefits than it adds to costs can and should be regarded as a cost-reducing modification. For example, if the realignment of a road to accomplish area development serves to raise costs (both financial and national economic costs) but raises benefits more than in proportion to these costs, the relative costs of the project may be said to have been reduced.

In summary then, three concepts of costs (financial, foreign exchange, and national economic) are applicable to any kind of cost reduction possibility that is being considered for the BPH. Moreover, in special cases such as consideration of labor-intensive construction of roads and highways, in order to be able to consider as a cost reduction situation such matters as a realignment of a road as a means of enlarging resettlement possibility, one can write of the reduction of national economic costs per unit of benefits.

D. METHODOLOGY FOR THE WORK

Details of the methodology adopted for the work are given in Appendices A and B. Appendix A is the project statement which was published at the beginning of the active work on 13 November 1972, and which set forth the concept of the project and the details of the work as far as these could be defined at the time the active work began. This statement was widely distributed including the mailing of copies to all district, regional, and city offices of the BPH.

Appendix B describes the separate steps followed in the course of the work. These were the issuance of the questionnaire that was assembled to solicit information, data, and opinions within the BPH organization; the program of field visits during February 1973 to selected BPH district offices; and the conducting of a seminar on 26, 27 and 28 March 1973, in order to provide a forum for the free exchange of ideas and views for three of the four topics (the utilization of computers was excluded) which were felt to have a controversial nature. The rationale for the planning and conducting of the seminar is discussed on pages A-11 and A-12 of Appendix A.

E. ACHIEVEMENT OF COST REDUCTION

The recommendations that result from the work are presented in the form of action plans, i.e., integrated sets of individual recommendation ready for action at the appropriate sequence. Each plan is ready for consideration with regard to its implementation in that the individual actions have been coordinated and organized in terms of facilitating the detailed planning of the implementation procedures. The PTAP judges the action plans to be technically feasible to implement. The primary basis for judgment has been that the institutions which would be involved to undertake the responsibilities for implementation already exist. The PTAP believes that the details which now follow with respect to the specific topics provide the economic basis for undertaking the implementation.

III BASES FOR ASSESSING COST-REDUCTION POTENTIALS

As the primary basis for assessing cost reductions, the PTAP chose to consider the entire road-construction program for the coming years foreseen for the Bureau of Public Highways (BPH), rather than to consider one particular road or highway construction project that might be termed "typical". Accordingly, the PTAP focussed its attention on making a realistic forecast of the BPH construction program through FY 1980. From this forecast, the PTAP then developed other data needed to make assessments for the specific topics chosen. One exception, however, has been the attempt to identify the labor-resource data for the country, which would be the input for evaluating labor-intensive construction of roads and highways.

A. THE ROAD CONSTRUCTION FORECAST

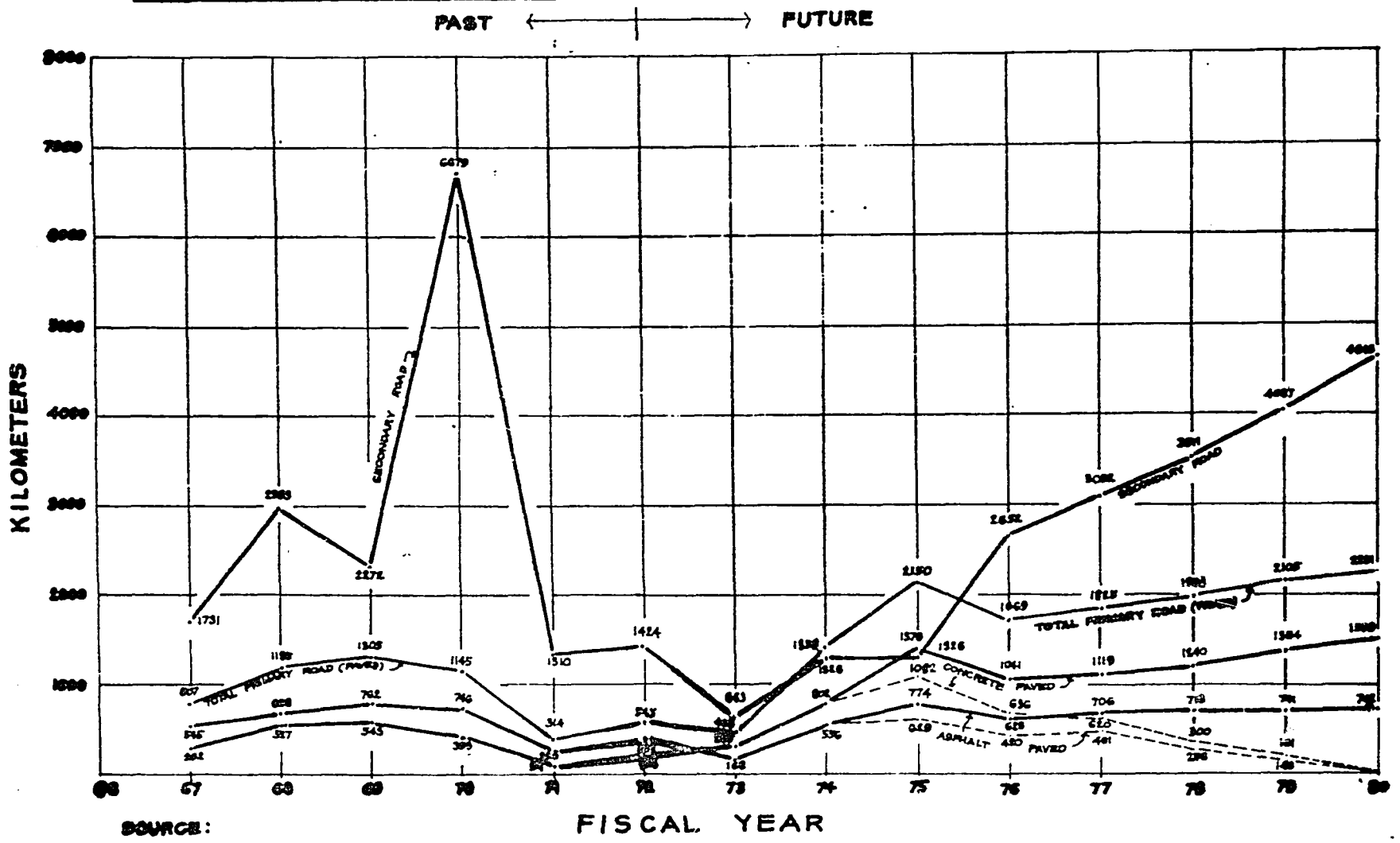
The forecast of future road construction through FY 1980 in terms of kilometer accomplishment is shown in Figure 1. Also shown in Figure 1 is the accomplishment of past road-construction programs beginning in FY 1967. Since the current records of the BPH range through the accomplishments during FY 1972, the forecast begins as of FY 1973. Three distinct categories of roads are labeled in Figure 1, according to whether a road is cement-concrete paved, asphalt-concrete paved, or gravel (unpaved). The first two categories are mostly in the primary system of roads, while the third category is mostly in the secondary system of roads.

With respect to past accomplishments, the data in Figure 1 are the actual lengths in kilometers constructed during each year. These data were taken from the records of the Coordinating and Statistics Section in the Construction Division of the BPH. This section is charged with keeping data and records, using information submitted to it by the different City and District Engineering Offices of the BPH. The data shown in Figure 1 between FY 1973 and FY 1980 inclusive are PTAP projections. The method for making these projections is shown and described in Appendix C.

Figure 2 shows expenditures which correspond to the past and to the forecast of future road construction programs. The format of the presentation in this figure is similar to that of Figure 1. Thus, past expenditures (up to FY 1972 inclusive) are taken from the records of the Coordinating and Statistics Section, while future expenditures (curve C) are the PTAP projec-

FIGURE 1

PAST ANNUAL ACCOMPLISHMENT AND FUTURE PLANNED PROGRESS FOR ROAD AND HIGHWAY CONSTRUCTION (F.Y. 1967 - 1980)

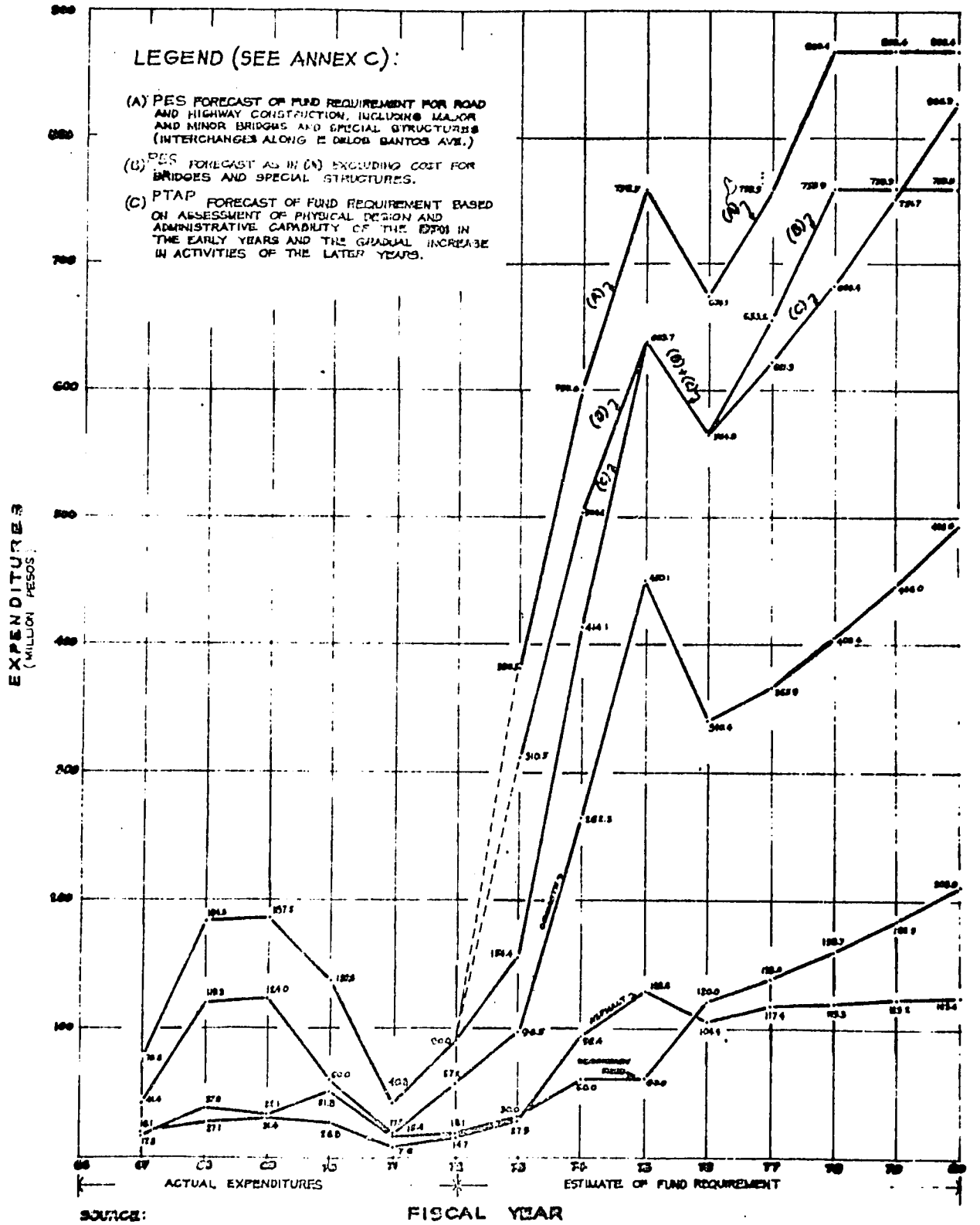


SOURCE:

1. BPH STATISTICS AND COORDINATING SECTION
2. PEB INFRASTRUCTURE PROGRAM (REVISED 1972)
3. FOREIGN ASSISTED PROJECT LIST

FIGURE 2

PAST ANNUAL EXPENDITURES AND FUTURE PROGRAM FOR CASH REQUIREMENT FOR ROAD AND HIGHWAY CONSTRUCTION


LEGEND (SEE ANNEX C):
(A) PES FORECAST OF FUND REQUIREMENT FOR ROAD AND HIGHWAY CONSTRUCTION, INCLUDING MAJOR AND MINOR BRIDGES AND SPECIAL STRUCTURES (INTERCHANGES ALONG E. DELOS SANTOS AVE.)
(B) PES FORECAST AS IN (A) EXCLUDING COST FOR BRIDGES AND SPECIAL STRUCTURES.
(C) PTAP FORECAST OF FUND REQUIREMENT BASED ON ASSESSMENT OF PHYSICAL DESIGN AND ADMINISTRATIVE CAPABILITY OF THE DPWH IN THE EARLY YEARS AND THE GRADUAL INCREASE IN ACTIVITIES OF THE LATER YEARS.
EXPENDITURES (MILLION PESOS)
ACTUAL EXPENDITURES
ESTIMATE OF FUND REQUIREMENT
FISCAL YEAR

SOURCE:

1 DPWH STATISTICS AND COORDINATING SECTION
2 PES INFRASTRUCTURE PROGRAM (REVISED 1972)

tions as developed in Appendix C.

The total program foreseen through FY 1980 can be summarized as shown in Table 2. Total expenditures for the period from FY 1973 until then could reach about 4,700-million pesos, for which a total of about 35,000 kilometers of primary and secondary roads would have been constructed.

B. THE CONSTRUCTION-LABOR RESOURCE

In order to assemble data and information with respect to the construction-labor resource of the country, the PTAP used three sources. The source of the first compilation is based on statistics from the results of the 1970 census. The data for the male population in the 20-49 year age group (the PTAP definition of the potential labor force in the nation) were aggregated by the BPH regional grouping of provinces and cities, and by the distribution of the force between urban and rural areas. This aggregation of the data is shown in Table 3. The census statistics were also aggregated to forecast the change in the labor force represented by this age group from 1970 to 1975. The method used was to add in the 15-19 bracket and subtract the 45-49 bracket. This second aggregation of data is shown in Table 4. Finally, using the census statistics on a national basis, the extent of unemployment is shown in Table 5.

The source of the second compilation are selected results of the Workshop on Manpower Resources held in October 1972 at the University of the Philippines campus in Los Baños which was sponsored by the National Economic Council (now NEDA - National Economic Development Authority). The selection refers to the unemployment comparison between metropolitan Manila and the entire nation. The data are shown in Table 6.

The source of the third compilation is a qualitative one, and is the result of the questionnaire distributed by the PTAP (Appendix B), specifically its section 1.4. Twenty district engineer's offices and nine city engineer's offices responded.

The PTAP presumed that the labor force which would be suited to work in labor-intensive road and highway construction would be male and ideally be in the 20-49 year age group. The data in Tables 3, 4, and 5 were assembled accordingly. Table 3 indicates that the labor force thus defined is by and largely located in the rural areas. Except for Region IV, which contains

TABLE 2

SUMMARY OF PTAP PROJECTIONS

BPH ROAD AND HIGHWAY CONSTRUCTION PROGRAM

ROAD CATEGORY	TOTAL ACCOMPLISHMENT Kilometers	TOTAL EXPENDITURES Millions of Pesos
Asphaltic-Concrete Paved	5,033	836.6
Cement-Concrete Paved	8,746	2,860.2
Sub Total Primary	13,779	3,696.8
Gravel Unpaved	21,210	959.1
Sub Total Secondary	21,210	959.1
TOTAL (All roads)	34,989	4,655.9

Source: Data in Figures 1 and 2

TABLE - 3

LABOR RESOURCE BY REGIONAL and URBAN/RURAL DISTRIBUTIONS
MALE POPULATION IN 20-49 YEAR AGE GROUP

REGION / PROVINCE		TOTAL	URBAN	RURAL
I	ILOCOS			
	TOTAL	262,364	47,536	214,828
	Percent	100.0	18.1	81.9
	Ilocos Norte	56,165	13,329	42,836
	Ilocos Sur	60,039	9,043	50,996
	Abra	24,074	3,761	20,313
	La Union	59,636	6,209	53,427
	Benguet	47,613	14,774	32,839
	Mountain Province	14,837	420	14,417
II	CAGAYAN VALLEY			
	TOTAL	287,855	39,927	247,928
	Percent	100.0	13.9	86.1
	Batanes	1,867	0	1,867
	Cagayan	99,331	14,034	85,297
	Isabela	110,802	14,582	96,220
	Nueva Viscaya	37,977	8,528	29,449
	Ifugao	13,907	897	13,010
	Kalinga-Apayao	23,971	1,886	22,085
III	CENTRAL LUZON			
	TOTAL	872,372	255,568	616,804
	Percent	100.0	29.3	70.7
	Pangasinan	227,529	44,305	183,224
	Tarlac	96,095	16,381	79,714
	Nueva Ecija	143,675	29,971	113,704
	Pampanga	149,443	48,881	100,562
	Zambales	65,547	35,354	30,193
	Bulacan	152,435	73,865	78,570
	Bataan	37,648	6,811	30,837
IV	SOUTHERN TAGALOG			
	TOTAL	1,575,837	1,033,572	542,265
	Percent	100.0	65.5	34.5
	Rizal	578,031	552,203	25,828
	Cavite	92,128	48,063	44,065
	Laguna	120,585	60,672	59,913
	Batangas	164,808	23,530	141,278
	Quezon	171,935	47,013	124,922
	Marinduque	24,786	2,850	21,936
	Oriental Mindoro	56,531	9,311	47,220
	Occidental Mindoro	24,855	6,349	18,506
	Romblon	25,837	2,977	22,860
	Palawan	43,708	7,971	35,737
	Manila	272,633	272,633	0
V	BICOL			
	TOTAL	471,542	89,380	382,162
	Percent	100.0	19.0	81.0
	Camarines Norte	43,342	11,214	32,128
	Camarines Sur	150,272	31,105	119,166
	Albay	109,269	14,633	94,636
	Catanduanes	23,432	3,953	14,469
	Masbate	79,342	12,581	66,761
	Sorsogon	65,885	15,883	50,002
VI	WESTERN VISAYAS			
	TOTAL	607,686	161,020	446,666
	Percent	100.0	26.5	73.5
	Negros Occidental	264,549	87,872	176,677
	Iloilo	196,694	54,209	142,485
	Antique	44,957	6,492	38,465
	Aklan	39,453	3,877	35,576
	Capiz	62,033	8,570	53,463
VII	CENTRAL VISAYAS			
	TOTAL	515,981	152,325	363,656
	Percent	100.0	29.5	70.5
	Negros Oriental	121,079	15,001	106,078
	Cebu	283,832	119,172	164,660
	Bohol	111,070	18,152	92,918
VIII	EASTERN VISAYAS			
	TOTAL	385,911	71,425	314,486
	Percent	100.0	18.5	81.5
	Northern Samar	48,963	9,457	39,506
	Eastern Samar	43,140	9,871	33,269
	Western Samar	72,016	8,080	63,936
	Leyte	181,811	38,141	143,670
	Southern Leyte	39,931	5,876	34,105
IX	WESTERN MINDANAO			
	TOTAL	333,291	53,924	279,367
	Percent	100.0	16.2	83.8
	Zamboanga del Norte	71,530	10,335	61,195
	Zamboanga del Sur	185,197	29,383	155,814
	Sulu	76,564	14,206	62,358
X	NORTHERN MINDANAO			
	TOTAL	541,751	112,194	429,557
	Percent	100.0	20.7	79.3
	Camiguin	9,396	2,546	6,850
	Misamis Oriental	82,610	17,415	65,195
	Misamis Occidental	55,143	8,755	46,388
	Bukidnon	72,432	9,508	62,924
	Lanao del Norte	66,098	5,934	60,164
	Lanao del Sur	84,794	20,951	63,843
	Agusan del Norte	51,080	18,766	32,314
	Agusan del Sur	34,738	6,285	28,453
	Surigao del Norte	38,971	8,966	30,005
	Surigao del Sur	46,489	13,068	33,421
XI	SOUTHERN MINDANAO			
	TOTAL	579,334	124,008	455,326
	Percent	100.0	21.4	78.6
	Davao del Norte	84,174	17,506	66,668
	Davao Oriental	45,493	9,374	36,119
	Davao del Sur	146,698	40,673	106,025
	Cotabato	216,429	31,274	185,155
	South Cotabato	86,540	25,181	61,359

Note: 1970 Census Data in their organization do not reflect the present political designations of cities as distinct from provinces.
Source: Advance Report - National Summary, 1970 Philippines Census, Bureau of Census and Statistics, Manila

TABLE 4
ESTIMATED INCREASE IN LABOR-FORCE 1970 to 1975
(MALE PERSONS, 20-49 YEARS IN AGE)

	Region	TOTAL				URBAN				RURAL			
		1970	1975	INCREASE	PERCENT	1970	1975	INCREASE	PERCENT	1970	1975	INCREASE	PERCENT
I	Ilocos	262,364	305,330	42,966	16.4	47,536	56,212	8,676	18.3	214,828	249,118	34,290	16.0
II	Cag. Valley	287,855	343,676	55,821	19.4	39,927	48,627	8,700	21.8	247,928	295,049	47,121	19.0
III	C. Luzon	872,372	1,032,684	160,312	18.4	255,568	300,053	44,485	17.4	616,804	732,631	115,827	18.8
IV	S. Tagalog	1,575,837	1,829,711	253,874	16.1	1,033,572	1,190,784	157,212	15.2	542,265	638,927	96,662	17.8
V	Bicol	471,542	571,566	100,024	21.2	89,380	110,731	21,351	23.9	382,162	460,835	78,673	20.6
VI	W. Visayas	607,686	719,292	111,606	18.4	161,020	190,348	29,328	18.2	446,666	528,944	82,278	18.4
VII	C. Visayas	515,981	600,772	84,791	16.4	152,325	177,669	25,344	16.6	363,656	423,103	59,447	16.3
VIII	E. Visayas	385,911	456,265	70,354	18.2	71,425	84,799	13,374	18.7	314,486	371,466	56,980	18.1
IX	W. Mindanao	333,291	390,307	57,016	17.1	53,924	63,540	9,616	17.8	279,367	326,767	47,400	17.0
X	N. Mindanao	541,751	630,780	89,029	16.4	112,194	132,988	20,794	18.5	429,557	497,792	68,235	15.9
XI	S. Mindanao	579,334	679,205	99,871	17.2	124,008	145,660	21,652	17.5	455,326	533,545	78,219	17.2
	TOTAL	6,433,924	7,559,588	1,125,664	17.5	2,140,879	2,501,411	360,532	16.8	4,293,045	5,058,177	765,132	17.8

SOURCE: Advance Report - National Summary, 1970 Philippines Census, Bureau of Census and Statistics, Manila; and PTAP

TABLE 5

EXTENT OF UNEMPLOYMENT (1970)

MALE POPULATION. 20-49 YEAR AGE GROUP

		NATIONAL TOTAL	URBAN	RURAL
1.	HOUSEHOLD POPULATION OF AGE GROUP	6,433,924	2,140,879	4,293,045
	Percent	100.00	33.27	66.73
2.	HOUSEHOLD POPULATION			
	a. Numbers Employed	5,298.641	1,701,741	3,596,900
	Percent of Total	82.35	26.45	55.90
	Percent in Category	100.00	32.11	67.89
	b. Numbers Unemployed	248,453	91,447	157,006
	Percent of Total	3.86	1.42	2.44
	Percent in Category	100.00	36.80	63.20
3.	TOTAL EMPLOYABLES (2a + 2b)	5,547,094	1,793,188	3,753,906
4.	UNEMPLOYED, % (2b)/(3)x100	4.5	5.1	4.2

SOURCE: Table A-4, Advance Report, National Summary Philippines 1970 Census of Population and Housing. Note: Data are estimates based on a five percent sample of the census.

TABLE 6

COMPARISON OF UNEMPLOYMENT IN SELECTED YEARS

(Metropolitan Manila vs. Nation)

	October 1965		October 1966	
	Metropolitan Manila	Nation	Metropolitan Manila	Nation
1. Total Labor Resource	1,086,000	10,764,000	1,107,600	11,757,200
2. Total Employment	915,600	10,101,000	948,400	10,936,200
a. Percentage	74,3	93.8	85.6	93.0
3. Distribution of Employment				
a. Agriculture, No.	n.d.	n.d.	18,800	6,290,000
%	-	-	2.0	57.5
b. Non-agriculture, No.	n.d.	n.d.	929,600	4,646,200
%	-	-	98.0	42.5
4. Unemployment, No.	170,400	663,400	159,200	821,000
a. Unemployed%who have	15.7	6.2	14.4	7.0
worked before, No.	49,200	228,000	38,800	348,000
%	28.9	34.8	24.4	42.4
b. Unemployed who have never work before, No.	121,200	435,400	120,400	473,000
%	71.1	65.2	75.6	57.6
5. Unemployed who have worked before				
a. In Agriculture, No.	n.d.	n.d.	800	162,400
	-	-	2.1	46.8
b. In non-agriculture, No.	n.d.	n.d.	38,000	185,600
%			97.9	53.3

Note: n.d. = no data.

Source: Rañoa, Milagros "The Work Force in the Philippines, 1958-1968" Workshop on Manpower and Human Resources 1972, National Economic Council, University of the Philippines, Los Baños, Laguna.

metropolitan Manila (including much of Rizal-province), the distribution is in the order of 80% rural and 20% urban. The distribution for Region IV is reversed, 65% urban and 35% rural.

Table 4 shows the estimated increase in the labor force between 1970 and 1975, established by including the current 15-19 year age group and eliminating the 45-49 year age group. A substantial increase in the labor force will accordingly occur over the five year period. The percentage increase is about the same whether urban or rural, and is in the order of 17 percent. Thus, if all those in the 20-49 year age bracket in 1975 were to seek employment, and if unemployment rates are not to increase markedly, then nationally over the five-year period from 1970 to 1975, about 360,000 new urban job opportunities and about 760,000 new rural job opportunities need to be found.

Table 5 shows the national unemployment level in 1970, according to a five-percent sample of the census returns. The data indicate overall a higher (5.1%) rate in the urban areas as compared with the rural areas (4.2%).

The data reported in Table 6 show that in 1965 and 1966 the unemployment levels in metropolitan Manila were considerably higher than for the entire nation as a whole. The unemployment rate in Manila ranged around 15 percent of the total labor resource, while this level for the nation was around 6.5 percent. The data for the table were developed through field interviews of a selected sample of the population.

More recent data on unemployment in the Manila area were reported in the 1972 Workshop. Prof. Gliceric Abad estimated from available statistics and from results of surveys undertaken by others that in metropolitan Manila in 1970 the number of unemployed was about 96,500, or 7% of the labor force. He estimated that this rate was lower than the national rate, and, if so, it would indicate that the unemployment situation had reversed its pattern from that shown for 1966 in Table 6. On the other hand, only one year later the unemployment rate in metropolitan Manila is said to have jumped to 10.2% of the labor force.

Mangahas* has summarized historical Philippine unemployment data. This summary is reproduced as Table 7.

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* Mangahas, Mahar, "A Broad View of the Philippine Employment Problem" Discussion Paper 72-26, Institute of Economic Development and Research, School of Economics, University of the Philippines, December 4, 1972

TABLE 7

Philippine Unemployment Rates, 1957-1971

Survey Date		National	Urban	Rural
1957	May.	8.7		
	Oct.	10.0		
1958	May	9.1		
	Oct.	7.1		
1959	May	7.7		
	Oct	7.2		
1960	Oct.	5.9		
1961	May	8.6		
	Oct.	6.3		
1962	May	9.5		
	Oct.	6.4		
1963	May	7.8		
	Oct.	4.6		
1964	May	6.4		
	Oct.	6.2		
1965	May	8.2		
	Oct.	6.2	10.7	4.1
1966	May	7.2		
	Oct.	7.0	10.0	5.7
1967	May	8.2		
	Oct.	7.7	10.3	6.6
1968	May	7.8		
	Oct.	7.9	9.0	7.4
1969	May	6.7		
1970	May (Census	7.7		
1971	March	5.4	7.7	4.3
	May	4.8	9.0	3.0
	November	5.3	8.6	3.8

Source: Bureau of the Census and Statistics Labor Force Surveys; Mijares and Ordinario (1972). Quoted by Mahar Mangahas, op. cit.

Between April and August 1971, a team from the Institute of Philippine Culture* interviewed a sample of 479 persons from the Tondo area of Manila. The results show that only 64 percent of those interviewed were in the labor force, and of this force the unemployment rate was 6.3%. However, 25% of the labor force interviewed were only sporadically employed.

The responses to the questionnaire regarding the labor force received by the PTAP were entirely qualitative, and presumably reflect the personal views of the responder. These views with respect to the unemployment situation in the districts and cities represented in the responses ranged from negligible to serious. Thus,

- in the Northern Luzon area, unemployment and underemployment is low. There is none in Nueva Viscaya, and it is negligible in Baguio City. It is low in La Union, but high in Benguet.
- in the Central Luzon area, unemployment and underemployment ranged from not serious in Pampanga to high in Bulacan.
- in the Southern Tagalog region, unemployment and underemployment are high. Cavite, Palawan, Occidental Mindoro and Oriental Mindoro reported high incidence of unemployment and underemployment. The same is true in urban centers within the region. In Quezon City, it is reportedly a major problem. Rizal province reported that no data were available while Quezon province did not report on the matter of employment and underemployment. There was no response from the Central Visayas region, nor from the Bicol region.
- in the Mindanao region, unemployment is reported as high.
- both Western Visayas and Eastern Visayas regions reported a high incidence of unemployment.

In summary, considerable information is available on the labor force of the country. Many persons have studied the character of the underemployment and unemployment problem. The schedule and scope of efforts the PTAP did not allow for a thorough investigation and assessment of the problem. Furthermore, even if it had been practical to make such an investigation, it is unlikely that the results would have been adequate for purposes of relating the

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* Hollnsteiner, Mary, Workshop Proceedings (1972)

size of the labor force, its geographical distribution, and its seasonal character specifically as an input for evaluating a program of labor-intensive road and highway construction. The main reason seems to be the lack of a suitable definition of what constitutes an unemployed person in the context of Philippine society, culture, and national economy.

C. INVENTORY AND FUTURE PURCHASES OF CONSTRUCTION EQUIPMENT

As will be noted, the PTAP focussed its attention on two types of construction equipment, namely: crawler-tractors (bulldozers) of the 120 HP and 180 HP class, and dump trucks of four and six cubic-yards capacity. The acquisitions of these units since 1967 are shown in Table 8. The data for this table are derived in Appendix D (Tables D-1, D-2, and D-3).

Also, shown in Table 8 are the expectations of future purchases of the equipment types selected based on the needs to support the road and highway construction which has been identified in Table 2. The basis for these expectations and the calculations are given in Appendix D. The major parameter shown in Table 8 is the service life that may be expected from the equipment units. Three levels are postulated, namely; 10,000 hours of useful operation; 20,000 hours; and 30,000 hours.

Inspection of Table 8 will show that, only if service life can be prolonged to 30,000 hours, will the rate of equipment acquisition for the types selected remain at the levels it has been. At the usual service life of 10,000 hours, acquisition rates can be more than three times the past experiences. Thus the increase in foreign-exchange demand for equipment purchases will be dramatic, if the projected road construction program is to be accomplished. This is especially so, because the Japanese reparations program is expected to be completed much before FY 1980.

D. FUTURE CEMENT CONSUMPTION

The PTAP projected the future consumption of portland cement of the Bureau of Public Highways in terms of the forecast of future road and highway construction (Table 2 and Figure 1). The result of the projection is shown in Table 9. The grand total of cement consumption over the period FY 1973 through FY 1980 is accordingly about 5.1 - million metric tons. The bulk of this quantity (4.6-million tons) would be consumed in the installation of cement-concrete pavement. The regional distribution of the projec-

TABLE 8

SUMMARY OF INVENTORY AND FUTURE PURCHASES
OF SELECTED CONSTRUCTION EQUIPMENT

EQUIPMENT TYPE	PRESENT INVENTORY(1) units	FUTURE PURCHASES(2) AT SERVICE LIFE OF 10,000 HRS. units	20,000 HRS. units	30,000 HRS. units
Crawler-Tractors				
120 HP	130	527	391	331
180 HP	451	1298	554	329
Dump Trucks				
4 cu. yd.	810	2985	2380	1570
6 cu. yd.	2100	6900	2900	2100

(1) Figures presume all equipment now deadlined is restored to service.

(2) Over the period FY 1973 through FY 1980 inclusive.

Source: Appendix D, Volume II

TABLE 9

PROJECTION OF CEMENT REQUIREMENT FOR
ROAD AND HIGHWAY CONSTRUCTION
(FY 1973 - FY 1980)

Year	For Lineal Roads (Metric Tons)	For Nominal Bridges[1] (Metric Tons)	For Interchanges (Metric Tons)	For Minor Drainage Structures (Metric Tons)	Wastage[2] (Metric Tons)	T o t a l (Metric Tons)
1973	155,170	10,620	1,940	4,090	4,180	176,000
1974	421,860	17,180	15,250	11,120.	9,590	475,000
1975	723,780	21,790	15,250	19,070	16,110	796,000
1976	547,570	19,270	80	14,430	11,650	593,000
1977	588,600	21,190	-	15,510	12,700	638,000
1978	652,240	23,320	-	17,190	14,250	707,000
1979	717,470	25,670	-	18,910	15,950	778,000
1980	793,740	28,230	-	20,920	17,110	860,000
TOTAL	4,600,430	167,270	32,520	121,240	101,540	5,023,000

Note: (1) Nominal bridges are those usually encountered and which represent no special features.

(2) Wastage is assumed to be $\pm$ 2% of the subtotal for the items shown.

ted cement consumption is shown in Table 10. These data indicate that there will be considerable emphasis in cement-concrete paving in Mindanao regions.

The procedures to establish Table 9 involved the following steps:

- The basic input data are Entry 16, items a and b of Table C-3b in Appendix C. For the kilometrages indicated in each year, a basic cement consumption of 526 metric tons per kilometer was used. This figure is based on a two-lane road of 6.7 meters paved width, 23 cm. thick pavement, and a concrete formulation to contain 8 bags (94 lbs. each) of cement per cubic meter in place.
- The cement consumption for the construction of nominal bridges is based on Table C-3a, Entries 3 and 5, of Appendix C. By subtraction, the expenditures for the nominal bridges were obtained. The 10% annual increase factor (as noted in Entry 6 of Table C-3a) was applied to the differences. Concrete bridges were taken at 56% of the expenditures, and steel bridges at 44% based on historical BPH experiences. Also from BPH experience, a factor of 10,000 pesos cost per lineal meter of reinforced concrete bridge was applied, and then a factor of 100 bags of cement applied per lineal meter. Cement used in the foundations for steel bridges was disregarded.
- The cement consumption for interchanges was established from the record of estimates already made in the BPH.
- The cement consumption for minor drainage structures was estimated by assuming one transverse culvert, 36 inches diameter and 18 meters long, per each 200 meters of road length. The cement consumption factor is 3.6 bags (94 lbs.) per lineal meter of culvert.

The procedure to establish Table 10 involved the following steps:

- Allocating the list of roads in Table C-1a and C-1b (Appendix C) to its respective region and isolating the corresponding cement quantities.
- For the construction of as yet unidentified road projects, shown in Entry 16b of Table C-3b (Appendix C), using the same regional distribution as found for the listed roads.

TABLE 10

REGIONAL DISTRIBUTION OF THE PROJECTED CEMENT REQUIREMENT

(F. Y. 1973-F. Y. 1980)

FISCAL YEAR	CEMENT REQUIREMENT IN METRIC TONS BY REGION (1)											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	TOTAL
1973	2,985	16,495	26,484	23,708	17,635	-	16,519	-	-	21,770	50,404	176,000
1974	25,759	32,129	69,337	56,220	34,931	13,764	34,427	629	-	80,773	127,031	475,000
1975	42,474	48,787	108,328	71,674	52,709	92,966	66,388	19,398	16,594	156,468	120,214	796,000
1976	40,995	27,978	67,264	42,808	24,500	112,226	46,788	23,436	28,025	142,994	35,992	593,000
1977	58,669	33,699	65,041	51,850	27,944	120,844	50,813	45,134	33,184	103,784	47,038	638,000
1978	74,581	53,635	62,176	70,086	49,001	77,529	57,069	63,367	54,807	85,521	59,228	707,000
1979	94,560	62,186	66,119	66,624	62,706	83,218	63,898	75,913	62,243	71,292	69,241	778,000
1980	85,977	86,091	83,251	86,030	86,574	11,459	85,098	86,123	86,147	76,398	85,852	860,000
TOTAL	426,000	361,000	548,000	469,000	356,000	512,000	422,000	314,000	281,000	739,000	595,000	5,023,000

Note: (1) The eleven regions of the country are designated as follows:

I - ILOCOS REGION
II - CAGAYAN VALLEY REGION
III - CENTRAL LUZON REGION
IV - SOUTHERN TAGALOG REGION
V - BICOL REGION
VI - WESTERN VISAYAS REGION
VII - CENTRAL VISAYAS REGION
VIII - EASTERN VISAYAS REGION
IX - WESTERN MINDANAO REGION
X - NORTHERN MINDANAO REGION
XI - SOUTHERN MINDANAO REGION

For the provincial component in each region, see Table 3.

IV LABOR-INTENSIVE CONSTRUCTION OF ROADS AND HIGHWAYS

Official policy of the Government is to encourage labor-intensive methods in the activities of the nation as a means of stimulating national development. The purposes of this chapter are to explore from two points of view the application of this policy to the construction of roads and highways, namely:

- the feasibility of maintaining the current specifications for the quality of the finished road and the desired completion rate for a project when labor is used more intensively in the construction; and
- the identification of opportunities to reduce costs when labor is used more intensively in the construction.

Labor-intensive construction methods were the predominant means of road construction in the Philippines prior to World War II. Since the liberation, however, machine methods have been introduced and their use expanded so that today capital-intensive methods are the predominant means of road and highway construction.

A. BACKGROUND

There is a current worldwide interest in the subject of the greater use of labor in the construction of infrastructure. Many actual construction experiences resulting from this interest are well known and may possibly be applied to the Philippines. Also, financial institutions are becoming aware of the need to consider the more appropriate use of labor in the projects they consider for finance. The loan practices of these institutions in general seem to have encouraged capital-intensive construction methods.

1. Current Foreign Activity

The PTAP has noted the interest in the subject by international organizations.

a. Views of ECAFE

In May 1972, the Highways and Highway Transport Sub-Committee of the Transportation and Communications Committee of ECAFE reported a number of observations and recommendations concerning the maximum utilization of

manual labor for low-cost roads. The report reflects also the views of the International Labor Organization (ILO). A summary is the following:

- At a sufficiently early stage before decisions are taken and commitments made, the planning authorities should examine what part of the nation's construction program can be carried out on a labor-intensive basis without any substantial increase in cost. Construction cost data presently available to planners generally understate the scarcity value of the capital and foreign exchange resources required for capital-intensive construction.

- Comparative cost data from projects executed both capital-intensively and labor-intensively are needed; factors contributing to success or failure in labor-intensive execution need examination; research is required into the use of labor and local materials, including research into the development of tools best suited to the local conditions, the practices, and the traditions in developing countries.

- The International Bank for Reconstruction and Development (IBRD), the Asian Development Bank (ADB), and other aid or loan-giving agencies should consider making provisions for the possibility of using labor-intensive methods, local resources, and intermediate technology in the projects and programs which they help to finance.

- For low-cost roads, manual methods of construction can be used with great advantage without sacrificing the quality. For certain operations, such as compaction and consolidation of soil and gravel, some equipment is needed in order to achieve the desired standard. The employment of manual labor would primarily depend upon the availability of cheap labor in the area where low-cost roads are planned. Except for the road roller, which can be manufactured locally and is in fact being produced in many countries, no sophisticated equipment or machinery is needed for the construction of low-cost roads.

b. <u>The Project of the IBRD</u>

For the past two years the World Bank (IBRD) has been engaged in the

active study of the issue of the appropriate input mix of labor and equipment in road construction. Accordingly, the Bank has undertaken an in-depth study of the technical and economic aspects of the problem with the assistance of four consultant firms. Two firms have devoted themselves to the economic aspects, and they are

- The Economist Intelligence Unit (EIU), of London; and
- The Societe d' Etudes pour le Developpement Economique et Social,(SEDES) of Paris.

The remaining two firms have devoted themselves to the technical aspects, and they are

- Scott, Wilson, Kirkpatrick and Partners (SWKP), of London, and
- Bureau Central d' Etudes pour les Equipments d' Outre-Mer, (BCEOM) of Paris.

The results of the work to date have been the development of analytical tools which may be used by the Bank, and in countries where the problem of labor utilization is of large magnitude. The basic analytical tool is a linear-programming model which can serve to explore the technical possibilities of substituting labor for capital (i.e. machinery) in the construction of roads, and then to determine the economic feasibility of a substitution. The basis for the model design incorporates both national economic costs and financial costs.

The linear-programming model was developed and tested using data on labor productivity assembled from a search of the published literature. As the result, an operable model has been developed and tested, but the productivity data has been found to be inconsistent and unreliable for the goals to be achieved. Productivity data of a wide scope is needed in order to be able to collect basic information on the labor force for a specific country in a relatively easy manner, to define its character, to define the effects of the environment on the completion of the construction work, and other basic data that may be relevant to the determination of labor productivity in the various tasks associated with road construction in developing countries. Then one should be able to predict the labor productivity (i.e. production function) for use in the model from a relatively few measurements or available data.

The Bank accordingly commissioned its consultant SWKP to undertake a comprehensive collection of productivity data from various road construction projects in India through direct field observation. Possibly, other countries may be included in this effort. Work in the field began in early 1972, and presumably at least the field work should have been completed at this writing.

Thus, although a useful analytical tool has been developed for use in identifying appropriate technologies for road construction in developing countries, reliable correlations of labor productivity as influenced by the environment and the motivation of the labor force are not yet available. Accordingly, the usefulness of the IBRD work and its applicability to Philippine conditions is not yet clear.

2. Some Foreign Experiences

The PTAP noted certain foreign experiences of relevance.

a. Tin Mining in Nigeria

This experience of more than twenty years ago concerns the mining of tin-ore on the Jos Plateau in Northern Nigeria. The tin-ore deposits lie about 30 to 50 meters below the surface of the ground, and the method used to extract the ore is the conventional open-pit mining operation. The sterile earth composing the overburden has to be removed to expose the ore beds. The earth moving operations may be considered to be similar in nature to those involved in road construction.

Up to the mid 1950's, the excavation of the open pit (i.e., the digging), the transport, and the disposal of the overburden were all undertaken by labor-intensive methods. The capital equipment used were hand shovels and metal pans of a size suited to head loads. The area of the pit excavated was in the shape of a rectangle, perhap 100 by 300 meters.

Masses of people were employed. Human conveyor belts were organized so that head loads of perhaps twenty kilos each could be passed from one person to another, each person moving a short distance to and fro each time. Empty pans were moved by the same people in the same belt but in the opposite direction in order to return to the point of excavation. So many people worked in the area that presumably , if one took a bird's-eye view of the site, practically no bare ground would be seen.

The event that cancelled the entire operation is significant. It was the introduction of the mechanically-powered capital-intensive dragline excavator. The basic reason for this change was the increase in the average daily wage paid the laborers from an equivalent of about 50 centavos to an oquivalent of about 75 centavos. Obviously, so much was known about the productivity of the labor force that the management of the mine, in this case a private-enterprise organization, was able to justify the capital investment involved to make the change, and then to obtain the necessary funds to accomplish it.

No information is available to the PTAP about the effects of the loss of employment on the economy of the area when draglines were introduced. Possibly, the change from labor intensiveness to capital intensiveness that was made raised the national economic cost of the mine operation. Certainly, it must have reduced the financial cost to the mine owners.

b. The Taiwan Experience

The experiences in Taiwan between 1957 and 1960 during the construction of the East-West Cross Island Highway provides an example of the prosecution of a large labor-intensive road-construction project. This highway is located in northern Taiwan. It extends from Taroko (Hualen) on the Pacific Ocean coast to Tungshih (Taichung) on the west coast, and the main road link covers a distance of 194 kilometers. The total network is about 300 kilometers long. Ten thousand workers were employed over a period of forty-six months to build this road at a cost of nearly US $11-million. Because of the difficult terrain, the highway is said to be an engineering marvel of the first magnitude.

The prime purpose of its construction was to open up the central mountain range that spines Taiwan from north to south to development through farming, cattle raising, logging, and tourism. Information presented during the PTAP Seminar indicates that this purpose was successfully achieved.

The Taiwan experience seems to be an analogous situation to what might be expected from the construction of a road from Marikina to Infanta crossing the Sierra Madre range. Thus, the experiences from Taiwan might be applicable in the Philippines in the construction of such a road by labor-intensive means.

c. Other Experiences

The Government of Colombia, through its Fondo Nacional de Caminos Vecinales, has for some years been sponsoring a "pick-and-shovel" road construction program in the rural areas of the country. In this program, farmers contribute their labor during the seasons of the year when farm needs are light for constructing farm to market roads. The Fondo construct the facilities that require capital investment, such as bridges. The objective is to raise prices received by the farmer for his produce by giving him direct access to the markets, rather than by letting him depend on a middle-man who is equipped to transport produce over poor or non-existent roads. The new rural roads stimulate greater competition among the transporters and consequently reduce the cost of transport to the farmer. The promise of receiving higher prices for his farm output apparently is the reason the farmer requires to motivate him to contribute his labor during his spare time. The program is considered to be quite succesful in raising prices received by the farmer without raising them at the same time to the consumer.

B. CURRENT PHILIPPINE ACTIVITY

The Philippine govenment has already taken distinct actions aimed at the implementation of its policy to encourage labor-intensive methods.

1. The Formation and the Work of the Coordinating Committee

In October 1972, the Department of Public Works, Transportation and Communications (DPWTC) established a Coordinating Committee on Labor-Intensive Construction Methods. The directive specified the following objectives for the work of this Committee.

- the identification of infrastructure activities wherein intensive use of manual labor may be applied;
- the comparison of costs among the different construction methods;
- the confirmation of these comparisons through field study; and
- the exploration of new construction methods or techniques which are labor oriented.

The first activity studied by the Committee was earth-moving. Data were gathered at the levee repair/construction work north of the bridge at

Manaatian (Pampanga), where 750 meters of levee were completely washed out by the 1972 floods, and an additional 400 meters were partly eroded. This levee is part of the Pasig-Potrero Flood Control Project. The Committee compared the cost of earthwork per cubic meter using a D-7 Bulldozer with the unit cost of a labor intensive method using carabao-drawn bull carts to haul earth from borrow pits over varied distances (25-100 meters) to the unloading site at the levee.

Another activity of the Committee was to conduct experiments at the Bued Asphalt Plant (at km. 215, Manila North Road), which continuously operates to produce asphalt concrete mix. The results indicate that opportunities exist to introduce a wider use of labor in combinations of mechanical and manual operations without affecting the costs of production. The Committee believes that further studies, utilizing different combinations of equipment and labor, are warranted.

The Committee solicited the views of the BPH consultants (Kampsax/Berger) regarding the opportunities to substitute labor for equipment. The Consultants identified items of work in highway construction where they believe the use of labor-intensive methods suited. They listed

- Clearing and grubbing
- Repair, raising and widening of road shoulders
- Widening of roadway on side hills
- Small drainage structures
- Aggregates production
- Construction of base courses and surfacing
- Construction of drainage ditches
- Erosion protection

The Consultants also emphasized that the key to all labor-intensive projects is supervision and control. Moreover, the engineer and the foreman must be at the job site almost all of the time if the quality of the work is not to suffer.

Finally, the Committee is scheduled to participate in a pilot road construction project employing labor-intensive methods. This project will be the construction of a 6-kilometer section of the Capas-Botolan road.

The project is expected to generate 26,560 man-days of work, broken down as follows:

Clearing and grubbing,	1,800 man-days
Earthwork (excavation & hauling),	23,400 man-days
Spreading & compacting base course,	300 man-days
Construction of drainage works,	400 man-days
Construction of wooden bridge,	660 man-days
	26,560 man-days

The project is expected to employ about 350 workers on the basis of a 6-day work week over a 3-month period. At this writing, work has not yet started, although the original schedule called for a period of construction extending through March, April, and May 1973.

2. Formation of the Cabinet Coordinating Council

In January 1973, the Government formed a cabinet level Coordinating Council for Labor-Intensive Operations by executive order. The Council is to provide top-level guidance and thereby expedite the decision-making and clearance functions. Moreover, the Council has the specific responsibility for insuring continuing study on labor-intensification of development projects, for assignment of projects to this method, and for consistency of application. It is to provide a coordinated and an integrated implementation of a labor-intensive scheme on an area basis, which necessarily involves various departments and agencies of the national and local governments. Thus, the Cabinet Coordinating Council for Labor-Intensive Operations is composed of the following:

Secretary of Public Works, Transportation and Communications	-- Chairman
Undersecretary for Home Defense	-- Member
Undersecretary of Education	-- Member
Undersecretary of Agriculture	-- Member
Undersecretary of Agrarian Reform	-- Member
Undersecretary of Labor	-- Member
Undersecretary of Community Development	-- Member

Undersecretary for Social Welfare (Programs)	- -	Member
Representative from NEDA	- -	Member
Director, National Manpower & Youth Council	- -	Member

The DPWTC Coordinating Committee on Labor-Intensive Construction Methods is to serve as the technical working group for the Council. The technical working group will be expanded as required to include representation from other departments or agencies of the Government.

3. Technical Results

The Committee has reported that the technical results of the levee repair and reconstruction work indicate that

- Costs. Labor-Intensive methods can compete on a financial-cost basis with equipment-intensive methods. On the basis of national economic cost, labor-intensive methods can be more attractive than equipment-intensive methods. Cost experiences in earth moving are reported in Figure 3.

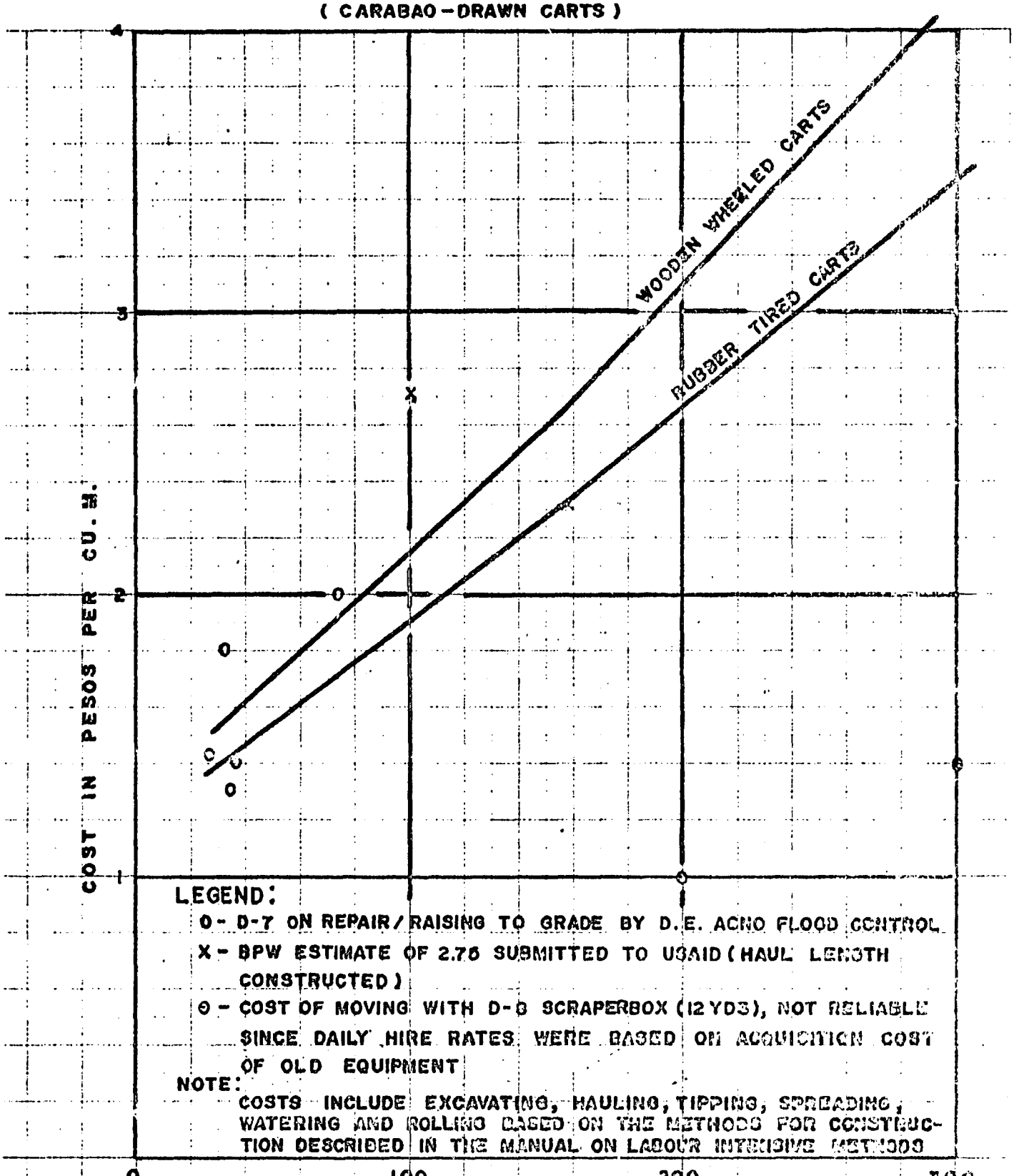
- Speed of Construction. Labor-intensive methods achieved a daily output of 1,500 cubic meters per day. This output is equivalent to the daily output of 4 or 5 D-7 bulldozers.

- Technical Acceptability. As far as carting and spreading the fill are concerned, the labor-intensive method is technically sound. Experiments on routing the traffic of the carabao-carts, and on watering and rolling to achieve the required degree of compaction, showed that results are as satisfactory as those obtained by the use of bulldozers, and that the results also are within the BPW specified requirement of 85%. Should a higher standard be required, then mechanical compaction (equipment-intensive methods) would probably be required.

- Employment Opportunity. The Bureau of Public Works has estimated that if about 30% of the total value of the Pampanga, Agno and Tarlac River Control Projects were to be performed with labor-intensive methods, then about a million man-days of work, (or 20,000 man-years) based on a work output of 6 cubic meters per man-day, would be involved. Assuming that these projects will be completed in two (2) years, a local

FIGURE 3

COST EXPERIENCES IN EARTHWORK HAULAGE BY LABOR-INTENSIVE METHOD
(CARABAO-DRAWN CARTS)



LEGEND:

O - D-7 ON REPAIR/RAISING TO GRADE BY D.E. ACNO FLOOD CONTROL

X - BPW ESTIMATE OF 2.76 SUBMITTED TO USAID (HAUL LENGTH CONSTRUCTED)

⊖ - COST OF MOVING WITH D-8 SCRAPERBOX (12 YD3), NOT RELIABLE SINCE DAILY HIRE RATES WERE BASED ON ACQUISITION COST OF OLD EQUIPMENT

NOTE:

COSTS INCLUDE EXCAVATING, HAULING, TIPPING, SPREADING, WATERING AND ROLLING BASED ON THE METHODS FOR CONSTRUCTION DESCRIBED IN THE MANUAL ON LABOUR INTENSIVE METHODS

SOURCE: MANUAL ON LEVEE CONSTRUCTION BY LABOUR INTENSIVE METHODS

labor force of 10,000 men, 4,000 carabaos, 240 water carts and 240 carabao-driven rollers would be needed. The water carts and rollers are inexpensive and could be manufactured locally if a program of efforts for this purpose were organized. Local barrio captains and farmers on the Pasig-Potrero (sugar area) and the Chico River (rice area) believe there should be no difficulty in finding this labor force within the barrios.

C. THE LABOR-INTENSIVE CONCEPT

Concepts of what exactly constitutes the labor-intensive construction of roads and highways differ, depending on the point of view of the participant in a discussion of the subject. Two extreme points of view seem worth illustrating. One might be termed a 100% labor construction technology, and the other a 100% capital-intensive technology. Thus:

- 100% Labor Construction. Hypothetically, one could picture roads being built only by people who cling to the mountain sides with their bare hands. They cup their hands to carry away earth, or they hold a rock to throw against another rock to break it up, so that the pieces can be carried away. People also jump up and down on loose earth to compact it - even carrying a companion piggy-back in order to achieve enough compaction. Some sophisticated technology is used, moreover, because other people are running down to the nearest spring to fill their mouths with water and then run back to water the subgrade, or the sub-base, or the base.

- 100% Capital Construction. Hypothetically, now that the space age has dawned, one could picture a road being constructed entirely by machinery remotely controlled by a central computer, whose program is based on the engineering designs of the road and feedback from mechanical or electronic sensors in the field. No person is involved. The engineering design itself may have been established by a computer.

Both of these illustrations suggest that the financial cost of a road built by either technology will be astronomical. Although many, if not an enormous number of, people can be put to work by the 100% labor approach,

the workers in effect would be not much more than beasts of burden.

The concept of the labor-intensive construction of roads and highways adopted by the PTAP, obviously has been an in-between approach. More specifically the PTAP concept involves the approach that recognizes that the nation has evolved in recent years into using a road-construction technology that is not appropriate for its national goals. Thus, in all probability, the capital content of the construction technology is too high and should be reduced by introducing labor in the appropriate places. The measure of appropriateness should be in the view of the PTAP, the minimization of national economic cost, and at the same time the use of labor in a technically feasible manner from the point of view of current BPH road performance standards and completion schedules. Essentially, the PTAP concept of labor-intensive road construction involves determining the size of a shift that should be made toward an increased use of labor in road construction which is appropriate to the economy of the country; and then recognizing that this appropriate shift is a dynamic one, i.e., its size changes and the nation's economy changes

D. PROBLEM AREAS

The PTAP has recognized that any effort to re-emphasize the position of labor in road and highway construction, such as by determining that a major shift toward labor use is warranted, will encounter obstacles to implementation of recommendations.

1. Institutional obstacles

Certain government policies and procedures most likely tend to discourage the use of labor-intensive methods. For example, the Contractor's License Law and the BPH prequalification requirements for prospective bidders have equipment ownership and possession as one of the factors for licensing and prequalification. Furthermore, the govenment specifications for construction of roads and bridges are equipment oriented. Specifically, Article 8.04 on page 55 of Standard Specifications for Highways and Bridges (Revised 1972) anticipates "that the Contractor shall furnish all the necessary construction equipment to assure satisfactory prosecution of the work". Further provisions in this Article are aimed at assuring that the Contractor provides the equipment specified in the proposal book as the minimum essential equipment required of him.

It will be noted later that broad social and economic considerations will be involved in the justification of a shift to more labor-intensive construction. This raises the prospect that conventional construction practices employed by the BPH may not be practical to follow in a large labor-intensive project. As an example, the present ceiling of about P2 million set for construction of roads by administration could discourage large labor-intensive road construction projects.

Attempts have been made in the past to stimulate the employment of labor in construction. An example in recent years is the activities of the Emergency Employment Administration during 1963-65. In general, experiences from this type of effort are considered to have been unsatisfactory in terms of the productivity achieved from the labor employed, and the unfortunate result for the present may be a general opinion among road designers to avoid the use of labor, if effective implementation of a project is to be achieved.

2. Financial Obstacles

The BPH operates annually on a financial cost basis, as do its contractors. The BPH is required to produce an accomplishment each year consistent with the financial money given to it as its budget. On the other hand, a more intensive employment of labor will have an effect on the national economic costs of the BPH construction activities. In a properly-managed effort, national economic costs can be reduced, but at the same time the financial costs may be increased.

National economic costs are the concern of government policy makers, and the results of considering them reflect in the budget allocations of financial money. The policy makers, therefore, must be aware of the need to allocate additional financial money where necessary to achieve reductions in national economic costs; while the BPH, in receiving additional financial money must be aware of the purpose of this extra fund - which is to employ more labor more effectively in achieving the current road accomplishment goal. If this mutual understanding does not prevail, a major obstacle to effective implementation of government policy to encourage labor intensiveness in construction will arise.

3. Need to Assure Benefits

If such a mutual understanding is to prevail, a given road construction project that is to use a labor-intensive technology must be conceived

to define precisely the benefits (social or economic) that will be generated thereby. The govenment policy makers can then have a basis for estimating national economic costs for that project in order to compare them when the current conventional technology in the Philippines is used and when a labor-intensive technology that the BPH considers technically feasible is used.

The given road project must also be conceived to define precisely the engineering obstacles to be overcome in order for the BPH to construct the road to satisfactory standards and within the desired time schedule, and to enable the BPH to estimate the financial costs involved on the basis of the use of its current construction technology and of the use of a labor-intensive technology.

The factors that should be considered in the given road construction project to assure that new social and economic benefits would be generated not usually considered in a conventional road feasibility study depend on what is perhaps the most important element in achieving more labor-intensiveness. This is to consider the construction of the road as an area development project rather than primarily as a project to connect two population centers most effectively. In this respect, a number of factors become evident:

- it should be practical to resettle families of the workers building the road progressively as sections of the road are completed; in order to produce benefits as early as possible by providing the worker who has completed his work an alternative to returning to the ranks of the unemployed;
- ideally, the entire labor force recruited in the construction phase of the road project should be permanently settled in the land opened up by the road, and remain there because the economic opportunities offered are attractive and adequate.
- non-road construction activities should be incorporated in order to provide the opportunity for resettlement (Examples are: construction of viable-agricultural land; community development incorporating health and education services; and financial services (e.g. a special bank) particularly during the early stages of settlement in new agricultural land); and

- the fact that some projects because of geographical location fit themselves only to labor-intensive construction should be recognized. (For example, the location of projects may be such that it is too costly to move in equipment, or the project may be so small that the cost of transporting equipment to and from the site are not justifiable).

4. Lack of a Basis for Estimating Costs

As already noted, the use of labor-intensive technology to construct public roads and highways in the Philippines is nothing new. Labor-intensive construction was the mode of the time before the last war. Since it was the only method available to build roads, it was the technology used to construct the network of roads that existed at the time of liberation, when equipment-oriented technologies were introduced in the Philippines on a large scale Some of the pre-war experiences is still retained in BPH through the services of the group of older personnel, but this experience is rapidly disappearing as the personnel retire.

On several occasions during the fieldwork, the PTAP attempted to elicit from the BPH personnel cost comparisons for a simple earth moving task between the use of labor primarily or the use of machinery primarily. These attempts were unsuccessful.

On the other hand, opportunities do exist for the establishment of a basis suited to the estimation of the financial costs of construction by a labor-intensive method. These opportunities are the following:

- the well-established "paquiao" system in the Philippines for contracting work by labor. The paquiao system (or takay basis) has been the usual method employed in the Philippine labor-intensive construction in order to assure high levels of labor productivity. The system includes a provision for trial periods with payment for actual costs in order to reach agreement on rates of payment. However, particular attention should be paid to the analysis of the tasks to be performed by labor, to the identification of the teamwork needed for efficiency, and to the use of the proper overall managerial techniques as important factors in assuring low financial cost levels and the completion of work to schedule.

- the earth-moving cost data developed for the Mancatian levee rehabilitation based on the carabao-drawn cart. Figure 3 shows the results in terms of pesos per cubic meter hauled, the distance of hauling, and the type of tires on the cart (wooden or pneumatic rubber).
- close observation of operations for the Capas-Botolan pilot project. So far there seems to be no comprehensive and reliable compilation of data and experiences that can be used for estimating costs of large-scale construction by labor-intensive methods for roads.

5. Need to Organize Data Collection

The data to be compiled for the Capas-Botolan Pilot Project will be perhaps the first effort of this kind in the country in many years. It will be the beginning of a compilation that could be used in the effective planning and accomplishment of labor-intensive road construction in the country as long as an undesirable employment problem exists. A procedure for collecting useful data from the experiences of this project has been developed through the joint efforts of the PTAP and the Department's Committee for Labor-Intensive Construction Methods.

a. Organization of the Labor Force.

The organization of the labor-force should first be charted. Initially, equal numbers of men might be assigned to each labor gang involved in the work. The number per gang and the number of gangs could vary during the course of the work. Changes in distribution of labor should be shown on a chart each week, and the reasons for changes from week to week noted.

b. Measurement of Accomplishment.

A complete set of drawings and written information could be prepared by the site-engineering office showing the details needed to measure accomplishment in the four areas of clearing and grubbing, earthwork, installation of base course and the installation of culverts. Of these, only the recording of accomplishment in earthwork will probably involve drawing work.

The drawing work will comprise the preparation before the project begins of a set of longitudinal profiles incorporating all the stations in the 6 km. stretch of right-of-way, and a set transverse profiles at

each station (one per sheet). About six longitudinal profile sheets and 300 transverse profile will be required, if a 20 meter interval for the transverse sections is selected.

The longitudinal profile sheets will show the planned profile and planned finished road grade to agree with the present design, and the revised profile and road grades, if the reconnaisance survey shows this is necessary. Each week, the new ground profile will be determined by survey, based on the earthwork completed and plotted on the corresponding sheet.

Likewise, the transverse profiles will show the original and revised initial ground elevations and desired elevations of the road surface. Each week the actual ground profile will be surveyed and plotted on the corresponding sheet.

The data as recorded above will then permit the analysis of accomplishment in terms of quantity moved and distance travelled.

c. Activities of the Labor Force.

The time cards for each worker could be filled in daily by the gang leader with data which includes:

- the station of the work keyed to the project drawing; and
- the nature of the work performed that day keyed to the tasks performed. The selection of the data to be recorded should enable the variations in the productivity of labor to be analyzed, and also the costs of labor in each type of operation to be established. The details here probably require considerable advance thought.

d. General Data.

General data includes tabulating on a daily basis climate, temperature, humidity, and rainfall distribution. On a general basis, they include recording:

- General Environment - Topography, geology, vegetation, and climate.
- Home Environment - Nutrition standards, level of adequacy of living conditions, existance and nature of social services, and level of health.

- Job Environment - Quality of tools and equipment, construction support, facilities supplied, equipment availability, and maintenance facilities.

e. Supervisory Force.

Time cards for supervisory, engineering and support personnel with a general description of activity and time spent could also be prepared and evaluated in order to determine a basis for estimating overhead costs.

E. CONSTRUCTION TECHNOLOGY

As parts of its job to promote mutual understanding with the government agencies concerned with national economic costs, the BPH faces two tasks. The first concerns the generation of knowledge regarding construction labor productivity and associate costs of accomplishments and this need has already been discussed above. The second concerns the identification of appropriate places for more intensive use of labor in the various construction activities.

The IBRD in its work to develop the capital-labor model referred to above, has identified the basic activities in road and highway construction where greater attention may put on the use of labor. This list is reproduced as Tables 11a and 11b.

The PTAP, based on Tables 11a and 11b, based on its interviews with field personnel of the BPH, and based on its own judgement for prevailing conditions in the Philippines, has identified the following summary of labor opportunities in road construction as the basis for BPH planning for introducing a more labor-intensive approach.

1. Clearing and Grubbing

Light vegetation and medium vegetation can be undertaken wholly by labor and tools under the paquiao system. Dense vegetation can be undertaken by labor and tools. Disposal of big trees outside of the right-of-way may be done with the aid of animals. In both cases the method of clearing employed by "kaingeros" will find ready application.

2. Selective Removal of Trees

This can be done by labor under the paquiao system.
Instead of cutting the trees at some distance above the ground thereby leaving a stump, cutting may occur at the roots to one side in order that the trees fall to the opposite side with the help of gravity.

TABLE 11a

LIST OF BASIC CONSTRUCTION ACTIVITIES
As Compiled by the World Bank

1.0 Site Preparation
- 1.1 Clearing and grubbing
  - 1.11 light vegetation
  - 1.12 medium vegetation
  - 1.13 dense vegetation
- 1.2 Stripping topsoil

2.0 Excavating Small Quantities
- 2.1 In soft material
- 2.2 In hard material
- 2.3 In rock

3.0 Excavating in Bulk
- 3.1 In soft material
- 3.2 In hard material
- 3.3 In rock

4.0 Loading
- 4.1 Homogenous loose materials (e.g. soil, crushed rock, stabilized materials, asphaltic concrete, etc.)
- 4.2 Other solid and packaged materials (e.g. bagged cement, drummed bitumen and petrol, lump rock, reinforcement, etc.)
- 4.3 Water
- 4.4 Other bulk liquids (e.g. bulk bitumen, fuel oil, petrol etc.)

5.0 Hauling
- 5.1 Up to 300 m
- 5.2 300 m - 2 km
- 5.3 Over 2 km

6.0 Unloading
- 6.1 Homogenous loose materials
- 6.2 Other solid and packaged materials
- 6.3 Water
- 6.4 Other bulk liquids

7.0 Spreading
- 7.1 Natural soils (for earthworks)
- 7.2 Unstabilized base and sub-base materials, quality factor
  - 7.21 high
  - 7.22 intermediate
  - 7.33 low
- 7.3 Stabilized base and sub-base materials, quality factor
  - 7.31 high
  - 7.32 intermediate
- 7.4 Bitumen macadam and asphaltic concrete, quality factor
  - 7.41 high
  - 7.42 intermediate
- 7.5 P.C. concrete for pavements, quality factor
  - 7.51 high
  - 7.52 intermediate
- 7.6 Cement/lime for stabilized bases, quality factor
  - 7.61 high
  - 7.62 intermediate
- 7.7 Bitumen for surface dressing, penetration macadam, etc., quality factor
  - 7.71 high
  - 7.72 intermediate
- 7.8 Gravel/sand for surface dressing, penetration macadam
- 7.9 Water (for compaction and curing, limewater for stabilization)

8.0. Mixing
- 8.1 Natural soils in situ (for mechanical stabilization, aeration, etc.), quality factor
  - 8.11 high
  - 8.12 intermediate
  - 8.13 low
- 8.2 Cement/lime with soils in situ, quality factor
  - 8.21 high
  - 8.22 intermediate
  - 8.23 low
- 8.3 Cement/lime with soils not in situ, quality factor
  - 8.31 high
  - 8.32 intermediate
- 8.4 Cold bitumen with soils in situ, quality factor
  - 8.41 high
  - 8.42 intermediate
- 8.5 Cold bitumen with soils not in situ, quality factor
  - 8.51 high
  - 8.52 intermediate
- 8.6 Hot bitumen with soils not not in situ, quality factor
  - 8.61 high
  - 8.62 intermediate
- 8.7 Bitumen macadam, quality factor
  - 8.71 high
  - 8.72 intermediate
- 8.8 Asphaltic concrete
- 8.9 P.C. concrete, quality factor
  - 8.91 high
  - 8.92 intermediate
  - 8.93 low

TABLE 11b (concluded)

LIST OF BASIC CONSTRUCTION ACTIVITIES

9.0 Compacting and Finishing

- 9.1 Bulk materials in earthworks, quality factor
  - 9.11 high
  - 9.12 intermediate
  - 9.13 low
- 9.2 Unstabilised bases and sub-bases, quality factor
  - 9.21 high
  - 9.22 intermediate
  - 9.23 low
- 9.3 Stabilised bases and sub-bases, quality factor
  - 9.31 high
  - 9.32 intermediate
- 9.4 Bitumen macadam, quality factor
  - 9.41 high
  - 9.42 intermediate
- 9.5 Asphaltic concrete
- 9.6 Surface dressing, quality factor
  - 9.61 high
  - 9.62 intermediate
- 9.7 P.C. concrete for pavements, quality factor
  - 9.71 high
  - 9.72 intermediate

10.0 Laying

- 10.1 Stone pitching
- 10.2 Brick soling
- 10.3 P.C. concrete linings (including connecting and finishing)
- 10.4 Masonry walling
- 10.5 Brick walling
- 10.6 Precast concrete products
- 10.7 Steel pipe culverts
- 10.8 P.C. concrete in foundations, headwalls, etc., (including compacting and finishing quality factor
  - 10.81 high
  - 10.82 intermediate
  - 10.83 low

11.0 Production of Local Materials

- 11.1 Rock for pitching/masonry
- 11.2 Coarse aggregate for water-bound macadam
- 11.3 Crushed rock for bases and sub-bases (i.e. Crusher run)
- 11.4 Coarse aggregate for bitumen macadam
- 11.5 Coarse aggregate for P.C. concrete asphaltic concrete
- 11.6 Coarse aggregate for quality factor
  - 11.61 high
  - 11.62 intermediate
  - 11.63 low
- 11.7 Coarse aggregate (chippings) for surface dressing
- 11.8 Fine aggregate, quality factor
  - (1) high
  - (2) intermediate
  - (3) low
- 11.9 Making bricks
- 11.10 Breaking bricks
- 11.11 Precast concrete units, quality factor
  - (1) high
  - (2) intermediate

12.0 Miscellaneous

- 12.1 Cutting, bending and fixing reinforcement
- 12.2 Formwork (including stripping) quality factor
  - (1) high (wrought)
  - (2) intermediate (rough)
- 12.3 Laying, trimming and compacting topsoil
- 12.4 Springging with grass, etc.
- 12.5 Seeding with grass, etc.
- 12.6 Brooming and cleaning surfaces

13.0 Management and Other *

- 13.1 Site overheads, logistic support, etc.
- 13.2 Head office overheads and profit
- 13.3 Administration
- 13.4 Mobilisation, including transport to site offices

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* This item from the World Bank list should be expanded to show more detail in the overhead costs arising from the "Work Brigade" concept. The level detail should be adequate to permit estimating overhead costs throughout the country as environmental conditions vary.

3. Stripping Operations

This is an easy job for labor using tools under the paquiao system.

4. Removal of Structures

a. Bridges - long bridges should be removed by machine methods. Short bridges can be removed by labor under the paquiao system.

b. Culverts, syphons and miscellaneous small structures can readily be removed by labor under the paquiao system.

5. Roadway Excavation

a. Soft and hardmaterials can be excavated by labor using hand tools. In soft materials, animals can be useful. The work can be accomplished under the paquiao system.

b. Rocks should be excavated using only machine methods and explosives in order to reduce financial costs. Compressors and pneumatic hammers are therefore indispensible equipment in such work. This practice should be followed when encountering rock formations in work described below.

6. Drainage Excavation

This type of excavation can be given entirely to labor under the paquiao system. Furthermore, for construction undertaken by contract, the contractor should be directed to perform this work entirely by labor intensive methods.

7. Excavation for Structures

a. Excavation for minor drainage structures can be undertaken entirely by labor.

b. Bridge foundation excavation above low-water level can be undertaken entirely by labor. For foundations below low-water level the use of a pump to remove water is mandatory. Furthermore, pumps should be available equipment because of the need to supply water for use of the laborers and for watering in building up the embankment.

8. Borrow Excavation

This activity can be undertaken by a combination of labor and animal power, except for hard material where labor only would be used.

9. Borrow Transport

The method of transporting borrow materials depends on financial

costs. Transport of materials by animal-drawn carts is one alternative where slopes in the route permit their use at competitive cost with capital machinery.

10. Building the Embankment

Spreading borrow or fill materials in building the embankment should be undertaken by labor. Compaction of the materials after spreading must be undertaken by mechanical compaction equipment because no alternative is available that can produce the necessary density in the compacted material.

11. Filling for Structural Foundations

Gathering of fill materials and its placing in the excavation for the foundation can be undertaken by labor. Hauling of the material from the sources is subject to cost analysis as noted above.

12. Subgrading

As noted above, except for compaction which must be done by capital equipment, all other work such as spreading and cambering can be done by labor.

13. Watering

Water can be supplied for any purpose by transport in motorized tankers.

14. Road-Protection Ditches

All work can be done by labor.

15. Spot Subgrade Reinforcement

Except for the hauling of materials as noted above, the work can be done by labor. Compacting by hand tamper is acceptable.

16. Base and Surface Courses

Hauling of materials can be by the least cost method. Spreading can be done by labor. Watering can be done by motorized water tankers. Compaction can be done by mechanical compaction equipment.

17. Structures

Structures lend themselves to maximum utilization of labor. Exceptions are the erection of prestressed concrete structures and the placing of sheet-piles, where equipment must be used. Therefore, these types of construction should be avoided when an acceptable labor-intensive alternative is available.

18. Miscellaneous Construction

Riprap, rock enbankment, curbs and gutters, side walks, catch boxes, manholes, inlets to underground structures, wood guardrails, underdraine, other incidental constructions can be done wholly by labor.

19. General Policy

In the view of the PTAP, the limit to which labor intensiveness in road construction can be brought, while complying the identification of labor usage outlined above, is one in which the labor-intensive construction technology that result meets the following criteria:

- the compaction specified in the road construction design can be achieved only through the use of externally or internally powered mechanical compaction equipment;
- financial costs can only be controlled at acceptable levels by excavating rocks with the aid of air compressors, pneumatic drills, and explosives;
- high levels of labor productivity can be achieved primarily by giving labor the maximum time for rest and relaxation through the use of motorized transport between the job-site and the home, when distances are excessive; and
- completion of roads projects to the desired time schedule requires that procedures adequate to manage the activities of large labor forces effectively be incorporated during the implementation of the construction project.

F. MANAGEMENT TECHNIQUES

Large-scale construction of roads by labor-intensive methods is characterized by the large numbers of people employed in the work at one time. This characteristic is different when capital equipment is used, since a relatively small number of machines would be required for the same work. Also, the factors determining the productivity of a laborer are far more complex to evaluate than for equipment. For labor, sociological and health aspects are significant, and most of these are difficult to predict. For equipment, all aspects are technical, are well known, and can be evaluated with certainty in order to predict performance.

Thus, some observations of differences in management between labor-intensive and capital-intensive construction may be made and they are the

following:

- it is easier to predict the productivity of machines than it is to predict that of human labor;
- the productivity of operations in capital-intensive construction depends primarily on the mechanical condition of the machine, whereas the factors that influence the productivity of labor are more complex;

  Some of these factors are:

  a) Tools and working methods,

  b) Planning and organization of the work,

  c) Workers physical condition and psychological attitude,

  d) Quality of supervision and management, and

  e) Condition of employment, including incentives and amenities.

It is clear that, just as thoughtfulness in preparing the work plan can produce a maximum productivity from the machines, similar thoughtfulness with respect to the work plan for labor-intensive construction can produce high productivities from the labor. But, such thoughtfulness in a labor-intensive orientation will require experience on the part of the manager which does not exist in the present BPH staff. The reason is that, for much of the career of the current senior personnel of the BPH, the construction operations have been largely capital oriented.

Therefore, any approach by the BPH into a large-scale labor-intensive road construction project should be undertaken on the basis that opportunity is given to the senior staff to gain experience in the appropriate management techniques. This will mean staging projects so that the risks of avoidable expenditures can be minimized, and also providing training for the selected senior personnel in the management tasks for a labor-intensive construction project based on modern techniques of managing the activities of large labor forces.

The historical paquiao system (or takay basis) is the appropriate base upon which to build the experience in large-scale labor-intensive construction, but at the same time, this system needs to be examined in terms of the

human factors involved which can act to prevent attaining a maximum productivity from a paquiao team. The specific objective in such an examination should be the identification of desireable changes that can increase the motivation of the team members. An example of such change might be the promise of land ownership in the area opened by the road project as part of the compensation paid for or as a fringe benefit of the work.

It would seem that the close parallel of the East-West Cross Island highway construction in Taiwan, already referred to, could provide much experience and data for transfer to a Philippine labor-intensive road construction project.

G. APPLICATION TO THE MARIKINA-INFANTA ROAD

The Marikina-Infanta road construction project, east of Manila has been indicated as a candidate by the Philippine government for construction by labor-intensive technology. It is about 130 kilometers in total length. The schedule calls for completion in 1976, and the road is to connect the towns of Marikina in Rizal province with Infanta in Quezon province which is located on the Pacific coast of Luzon. The area influenced by the road is mostly mountainous, and for much of the prospective length the land adjacent is publicly owned. The stretch beginning at Marikina for perhaps 30 kilometers, and the stretch near the Infanta end, traverses privately held lands, with subdivision activities already in progress near Marikina. A joint prefeasibility study for this road by the Presidential Economic Staff and the Project Planning Division of the DPWTC was issued in December 1972. An abstract of this study is presented in Appendix E.

Some construction is already underway. The first 3.94 kilometers are already under construction by a contractor employing conventional methods. The next 20 kilometer stretch has already been designed, and a notice for prequalification of contractors has already been issued. Preliminary location plans and profiles have been prepared for the remaining length, and these are now being reviewed by the field survey parties making the survey for the final plans.

The PTAP believes that the portion of the alignment of the Marikina-Infanta road not yet committed for construction represents an ideal candidate for construction as a prototype by labor-intensive means for a number of

reasons. These are:

- the uncommitted portion passes through publicly held lands that probably could be made available for resettlement by the workers on the construction;
- the metropolitan Manila area probably represents a higher level of unemployment than for the rest of the country, so that a labor-force could be recruited on a selective basis;
- the road alignment is close to the central headquarters of the BPH and the other government agencies which would be involved. Universities and other research institutions whose assistance would be required are nearby. Both of these factors enable close supervision and evaluation of the results or the ready solution of unforeseen problems;
- the metropolitan Manila area would be accessible to the new areas opened, and could offer a ready market for agricultural produce;
- this market could absorb higher-valued produce enabling smaller farm units to be viable; and
- the area of influence of the road has other potentials which have been identified by the feasibility study (Appendix E).

If the implementation of a prototype labor-intensive construction project for the remaining portion of the Marikina-Infanta road is to be successful in terms of achieving the national goal of reducing unemployment, certain specific objectives should be adopted in a plan of action. These are:

- the demonstration that the construction of the road is technically feasible by labor-intensive methods;
- the demonstration that the construction of the road by labor-intensive methods is economically feasible in terms of national economic costs;
- the demonstration that a schedule for the completion of the project can be established in advance with reasonable expectations that it will be met; and

- the demonstration that the quality of the construction will be equivalent to the quality expected in current construction projects involving similar terrains and environments.

The efforts that should be undertaken to achieve such objectives involve their selection to be responsive to a number of interim objectives such as the following:

- the compilation of comprehensive knowledge of the resources of the area traversed by the road, especially those which were identified in the prefeasibility study of the PES for further investigation in relation to the road construction;
- the compilation of comprehensive knowledge of the labor resource available for the construction program;
- the compilation of a body of sociologically-oriented knowledge about the Philippine laborer and of modern techniques for labor management aimed at identifying candidate methods to increase his motivation;
- the identification of the labor-intensive technologies that may be appropriate for the construction of the road in terms of achieving the construction of minimum economic cost;
- the estimation of both the national economic costs and the financial costs for the construction of the road, if conventional capital-intensive technology were to be employed and when the appropriate labor-intensive technology is employed;
- a comprehensive description of the area development to be realized as a result of the construction of the road and its capability to absorb the labor force, and others, as permanent settlers; and
- the estimate of the amount and the schedule of the employment that can be offered, both when the appropriate technology and the conventional technology are employed in the road construction.

The specific tasks to be undertaken and completed in order to achieve the limited objectives are the following:

- compilation of experiences in other countries who have constructed roads of similar scope as the Marikina-Infanta project using labor-intensive methods. Such an experience seems to be available in Taiwan in connection with the construction by 10,000 laborers of a 300-kilometer network during 1957-1960, now known as the East-West Cross-Island Highway;

- the formulation of the project management plan which anticipates the problems to be solved related to managing and supporting large numbers of men in a work force laboring over a number of years, including the problems of maintaining their motivation, their efficiency, and the required construction progress;

- definition of the non-road construction activities that must be incorporated in the master plan in order to generate the new social and economic benefits. (Examples are: construction of viable agricultural land; community development incorporating health and educational services; financial services (e.g., a special bank) particularly during the early stages of settlement in new agricultural land; development of mining resources; and the development of industry);

- incorporating in the designs dealing with the earthmoving operations (particularly in the mountainous areas) the prospects for contour leveling the land adjacent to the road to provide additional areas for agricultural purposes;

- giving consideration to the feasibility of incorporating such techniques for stimulating and raising motivation levels in the labor force as

  (a) educating the workers to a clear understanding of the social and financial aspects of the road project,

  (b) providing a level of savings acceptable to the workers such that they will have working capital should they eventually settle in the land opened by the road,

  (c) providing meals and food items on the job to assure adequate levels of nutrition, aside from using such feeding as compensation for work, and

(d) the educational and training needs to be incorporated in the support services to the work force to prepare the workers for the problems of resettlement, or to train them in skills and crafts for future employment.

- establishment of plan for recruiting the labor force which will consider the feasibility of recruiting from squatter settlements in the metropolitan Manila area, as well as from other sources;
- establishment of a plan for discharging the work force as required to take advantage of settlement opportunities as they arise.

One important action to be taken in all of the above should be to organize and evaluate the intermediate and final results as they become available, to provide a series of written guides to be used in the regional offices of the BPH for identifying and selecting road projects throughout the country which are suited to construction by labor-intensive methods, with the aim of effective and efficient implementation at the appropriate time.

V PROLONGING EQUIPMENT SERVICE LIFE

As already noted, capital-machinery methods for the construction of roads and highways have been introduced since the liberation on an accelerated scale, so that today the accomplishment of road construction projects largely depends on the use of heavy construction equipment. The purpose of this Chapter is to explore the potential to reduce the costs of road and highway construction through prolonging the service life of the heavy construction equipment owned by the Bureau of Public Highways.

In order to manage the work involved in reaching this purpose within the time available, the PTAP narrowed its efforts to concentrate on only two major types of equipment which together account for about 63% of the value of the equipment mix in the construction team for a typical road project. These two types are tractor crawlers of 120 and 180 HP and dump trucks of four and six cubic yards capacity.

A. BACKGROUND

The rise in the use of heavy equipment in road construction may be explained on the basis of the mechanism through which the post-liberation Japanese reparations payments are made, namely payments in the form of equipment; and the practices of international lending institutions. To maintain the desired rate for the construction of infrastructure, the government has had to take advantage of the loan funds available from international development banks. The methods adopted by these banks to manage the use of its loan funds tend to promote capital-intensive construction methods. The basic reason for this is their reliance on consultants and construction firms from the developed areas of the world, where capital-intensive methods are appropriate.

1. Current Inventory of BPH Equipment

The present inventory of the selected equipment types is derived more or less from purchase and reparations acquisitions since 1967. The details are shown at the bottom of Tables D-1, D-2, or D-3 in Appendix D. In summary, the current inventory consists of

Crawler-Tractors	
120 HP	130 units
180 HP	451 units
Dump Trucks	
4 cubic yards	810 units
6 cubic yards	2100 units

However, many of these units have been "deadlined". Table 12 shows the units deadlined as of 30 November 1972.

A deadlined equipment item is considered to be "on hand", i.e., it is available for use as soon as needed repairs have been completed. The completion of repairs or removal from deadlined status, depends on a number of factors the most important of which is the availability of all spare parts needed for the complete repair of the unit.

In December 1972, the PTAP explored the possible reasons for the high levels prevailing for deadlined equipment by sampling and inspecting items of deadlined equipment at the North Harbor Equipment Depot. These items were the following:

- a trailer-mounted diesel-engine driven air compressor which was brought in for nominal repairs in March 1965. The inspection showed that this unit was never repaired because of lack of parts involving an oil seal, o-ring, diaphragm, spring, and an compressor-oil pressure gauge. This equipment item was then stored outdoors and was rusting away under the influence of the weather. Most likely after about six or seven years of such exposure complete deterioration could occur. The compressed-air storage cylinders seemed no longer able to withstand design pressure. The manufacturer of the compressor unit was Jaeger, and he is not represented by a dealer in the country.
- a front-end loader which was brought in for nominal repairs in May 1968. The unit was never repaired because of lack of parts involving a vibration control in the clutch, hoses, special nuts and screws, clamps, all parts for the hydraulic-fluid system, oil seals, brake lining, and brake master cylinder. The inspection showed that this equipment item was then store out-of-doors and was rusting away under the influence of the weather. The manufacturer of the equipment has a local distributor who did not have the needed spare parts. Since the initial attempts to repair the unit, it had been cannibalized through giving up its steering booster unit to keep another equipment item of similar type in operation.
- a unit which had been completely repaired two years ago but still lacked a clutch plate. The inspection showed that it had been stored in the garage protected from the weather, but it would seemed that

TABLE 12

STATUS OF CONSTRUCTION EQUIPMENT IN THE BPR INVENTORY

1. ALL EQUIPMENT

June	On Hand	Serviceable	%	Deadlined	%
1968	5537	3836	66	1701	34
1969	6629	4614	69	2015	31
1970	8486	6013	71	2473	29
1971	8704	5898	68	2806	32
1972	8778	5068	58	3710	42
As of 30 November 1972	8658	4707	54	3951	46

2. TRACTOR CRAWLER

June	On Hand	Serviceable	%	Deadlined	%
1968	601	348	58	253	42
1969	752	480	64	272	36
1970	858	525	61	333	39
1971	1233	793	64	440	36
1972	870	431	50	439	50
As of 30 November 1972	850	376	44	474	56

3. DUMP TRUCKS

June	On Hand	Serviceable	%	Deadlined	%
1968	2428	1819	75	604	25
1969	2401	1717	72	684	28
1970	3501	2582	74	919	26
1971	3942	2722	69	1220	31
1972	3502	2085	59	1417	41
As of 30 November 1972	3482	1933	56	1549	44

it would never operate again. Should the missing part arrive, the engine maintenance would have to be done again. Most likely, it too would have been moved outdoors as soon as the space it occupied in the garage was needed for other purposes.

The sample of experiences noted above indicate that deadlining an equipment unit increases the chances that the unit ultimately will be disposed of rather than see useful service again. The need seems to exist to provide spare parts without delay at the time needed.

2. Local Manufacture of Spare Parts

The Philippine manufacturing industry as now constituted seems to have the capability to manufacture most of the spare parts which are needed for heavy construction equipment. A census of potential manufacturing enterprises in this respect, compiled by the Board of Investments, is presented in Appendix F.

3. Current Remedial Activities

Major efforts are now underway to remedy past practices and to secure longer service lives from the BPH equipment inventory. These efforts have been largely generated by the studies of the consortium of Kampsax and Berger.

Since mid-1971, Kampsax-Berger have been engaged in the development and implementation of plan for the reorganization of the Bureau of Public Highways, and the scope of their efforts includes attention to the Bureau's mechanical-equipment operations and servicing. One recommendation resulting from their work is a plan to reorganize all the functions of the present Equipment and Shop Division of the Bureau as a Mechanical Services Division. This Division would control a complete integrated mechanical services support organization in each Region in order to provide functioning equipment to the Regional Division Engineer as needed. The eleven Regions are shown in Figure A-2 (Appendix A) of the Project Statement.

The reorganization plan is now being implemented. One stage in the implementation is the operation of two pilot regional mechanical-services support projects, one in Bauang in Region I and the other in Cebu City (Cebu) in Region VII. The implementation of this stage started in April 1972.

In the two pilot schemes, the operations at each location are aimed at the ultimate establishment of a centrally-managed self-accounting organiza-

tion with executive and technical control of repair shops and mechanical-service facilities, with authority to procure and distribute spare parts, and with accountability for all equipment owned by the Bureau. In its ultimate form, such an organization will finance itself by imposing rental charges on the users of equipment sufficient to cover the applicable costs of owning, operating, and maintaining the equipment. The operational, procedural, and reorganizational details of the Kampsax-Berger plan are contained in Chapter 2 (pages 26 through 35 and 42 through 44), in Chapters 11 and 12, and in Chapter 16 (pages 19 through 23). In the two pilot schemes, the work involves testing, reviewing, and revising the details of the plan prior to a nationwide implementation in early 1973. The current schedule calls for the completed implementation by 30 June 1973.

One of the major changes in the BPH management practices for heavy construction equipment will be the installation and operation of a comprehensive preventive maintenance system in the regional shops, designed to detect problems in the equipment operation before they become serious. The details for this system are presented in Appendix G.

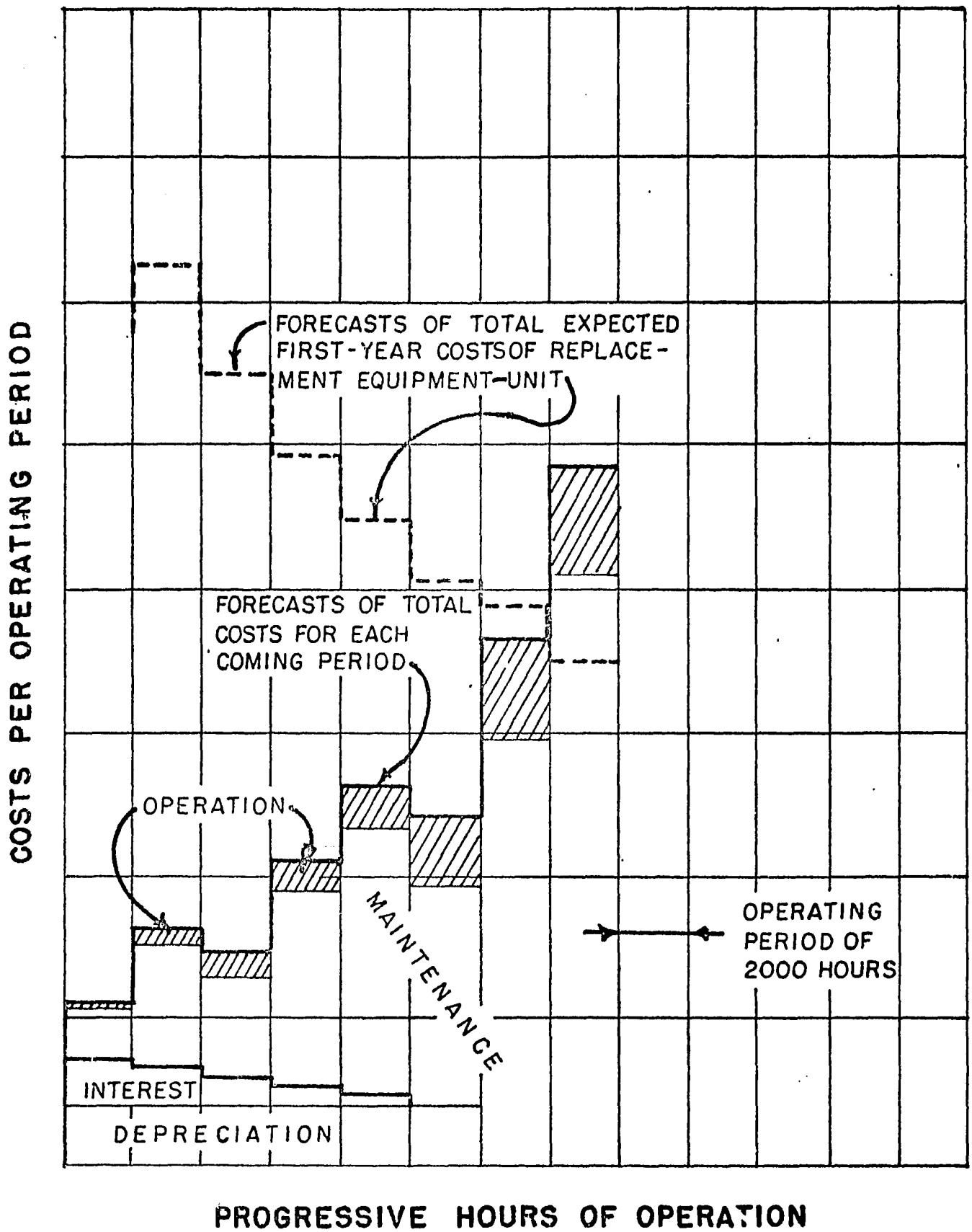
B. DEFINITION OF SERVICE LIFE

Any definition of equipment service life that is to be adequate is necessarily complex. Typically, if not always, the economically useful life of any piece of equipment is shorter than its technical operating life, that is to say, it is regularly worthwhile to retire equipment while it is still technically capable of operating. The point in time at which a given unit of equipment should be replaced depends upon a number of technical and economic factors. Briefly, replacement should occur as soon as the costs of owning, maintaining and operating the unit is higher per unit of output than the corresponding costs for the equipment unit that could replace it.

Perhaps such a concept of equipment service life can best be explained by a graph. Figure 4 is an illustration. In this figure, the ordinate, or vertical scale, represents the total cost incurred during a given number of hours of operation of a given equipment unit "X", which is attributable to the ownership, operation, and maintenance of that unit. Costs attributable to ownership include sums to cover depreciation and interest charges arising from loans made when the equipment unit was originally purchased. Expenses attributable to maintainance activities are defined as those arising from

FIGURE 4

SERVICE-LIFE DETERMINATION FOR EQUIPMENT UNIT "X"



activities necessary to keep the equipment unit in a technically acceptable operating condition. What is technically acceptable will usually be determined by the user in terms of his satisfaction that he actually attains the productivity expected from the equipment unit. Operating costs include the consumption of fuels and lubricants, and the wages of the operator.

The abscissa, or horizontal scale, represents cumulative hours of operation for the equipment unit from the time it was brand new. The number of hours of operation may or may not coincide with the actual number of hours that the equipment was available for use. One could expect that an operating period of 2000 hours will coincide with one year of equipment availability, if the unit is fully utilized.

Shown in Figure 4 are two different sets of step functions which ultimately, as the equipment unit "X" undergoes progressive hours of operation, intersect. The set of step functions which generally rises from left to right indicates the expectation at the beginning of each operating period as to total costs to be incurred for unit "X" during the coming period. If effective preventive maintenance is practiced, such predictions can be made with reasonable accuracy. Obviously, such predictions cannot foresee maintenance costs arising if unit "X" suffers an accident, or is abused by the operator. The forecast of costs includes depreciation, interest, maintenance, and operation chargeable to the coming period for the unit "X".

The set of step functions which characteristically falls from left to right indicates the cost that can be expected during the coming period if a new equivalent unit replaces unit "X" at the beginning of that period. These costs include depreciation, interest, maintenance, and operating costs of the new unit plus costs attributable to the loss from the disposal of the old unit incurred if the depreciation not yet recovered exceeds its disposal value.

The intersection of the two sets of functions indicates the point in time at which replacement of unit "X" with an equivalent new unit is justified by the cost situation. The cumulative time of operation of unit "X" may then be considered as the service life for this unit.

The method of recording illustrated by Figure 4 may also be used for plotting historical costs for an equipment unit and comparing them with forecasts.

C. LIMITING FACTORS

Some of the factors prevailing in recent years, which appear to have limited the service life of the construction equipment operated by the BPH are the following:

- as already noted, frequent inability of the equipment depots to obtain spare parts quickly when needed. Equipment deadlined for lack of parts were frequently subject to cannibalization, which in turn had reduced the likelihood they could ever be restored to useful service;
- prevailing personnel policies (apparently salary levels relative to private industry) within the Bureau of Public Highways which lead to an unstable staff roster. Experienced and trained personnel are lost to private organizations.
- lack of standardization in the makes of the equipment units which have been imported. A pattern of demand has resulted characterized by requirements of small quantities of many different part items. Such a pattern discourages local industry from investing and undertaking spare parts manufacture.
- choice of makes of equipment whose manufacturers do not maintain adequate stocks of spare parts, or provide service facilities in the Philippines.
- frequent lack of funds has prevented the purchase of needed spare parts even when they have been available.
- cumbersome administrative procedures have delayed procurement of readily-obtainable spare parts, even when funds were available, such delays providing opportunities to cannibalize almost completely-maintained equipment units.
- similar cumbersome procedures which have served to impede the procurement of readily available sundry consumable items (lubricants, filter, grease, e.g.) with consequent equipment deterioration which could otherwise have been avoided.
- lack of protected space in the repair base to store equipment awaiting missing parts, which results in storage out-of-doors and consequent deterioration from the weather.

D. THE INCENTIVE TO PROLONG SERVICE LIFE

The PTAP forecast of road and highway construction through FY 1980 has already been presented above (Table 2). Major capital expenditures will be required for new construction equipment to implement this future road building program presently facing the BPH. A summary of the PTAP estimates in this respect is presented in Table 13.

The PTAP assumed as a base level of service life currently experienced in the BPH, a figure of 10,000 operating hours (equivalent to 5 years). Actually, the criterion which has been followed by the Bureau of Public Highways up to recently is to repair equipment until a needed maintenance job costs 60 to 70% of the replacement cost of the unit. Presently, this guideline is under review as part of the work of the Kampsax-Berger Consortium.

The current experiences of the Bureau of Public Highways with the service lives of heavy construction equipment is varied. Cases can be found where an equipment unit has served only from 2,000 to 4,000 hours, when lack of spare parts cause it to be deadlined, and then later cannibalized to the degree that maintenance for restoration probably can no longer be justified. On the other hand, cases can be found of equipment that has been in service for ten to twenty years. Part of the reason for this variation is no doubt the difference of the severity of the service to which the equipment units have been subjected. Probably little is to be gained in attempting a historical evaluation of equipment service life from the records in the Bureau of Public Highways. An assumption of an averaged service life for all equipment units is probably sufficiently accurate for the purpose here, which is to estimate the effect of extended service life on new equipment purchases to be undertaken by the BPH through 1980. As already noted, only crawler tractors and dump trucks have been given attention.

For the selected equipment types at a service life of 10,000 hours, a total expenditure of U.S. $188-million will be needed between now and FY 1980. If service life could be exgended to 20,000 hours, the investment will be reduced to U.S. $98-million, a potential saving of U.S. $90-million Further, at 30,000 hours, the hypothetical savings might approximate U.S. $122-million. If acceptable equipment productivity were achievable through

TABLE 13

EQUIPMENT PURCHASE VS SERVICE LIFE

Service Life	10,000 Hours		20,000 Hours		30,000 Hours	
Tractor-Crawlers	Number of Units	Cost US $ x 10	Number of Units	Cost US $ x 10	Number of Units	Cost US $ x 10
120 HP	257	23.758	391	18.032	331	15.085
180 HP	1292	61.988	554	26.075	329	14.616
Dump Trucks						
4 Cubic Yards	2985	30.087	2380	24.576	1570	15.670
6 Cubic Yards	5900	72.090	2900	29.079	2100	20.163
Total Cost		187.923		97.762		65.534
Savings		0		90.161 *		122.389 *

* Referred to a 10,000-hour service life.

NOTE: Based on (1) anticipated requirements through 1980 and (2) a forecast of an annual increase of equipment cost which is constant at 5% and (3) considering only the types of equipment which represents 63% in value of the total investment for the typical equipment mix in a construction team in the field.

SOURCE: Compilation from Appendix D, (Volume II).

performing intensified maintenance to assure these extended service lives, the higher cost for the maintenance efforts would, of course, subtract from the indicated savings. The allocation of the savings indicated above to the different equipment types and sizes is shown in Table 13.

The observations that seem justified to make based on the analysis just presented are the following:

- a powerful incentive exists to identify and attempt to change further the BPH equipment management practices that can extend service life beyond those already being implemented;
- some desirable changes have already been identified;
- the foreign exchange component of the cost of maintaining an equipment unit is a considerable smaller fraction than the foreign exchange component of the cost of acquiring a replacement unit;
- the foreign exchange component of maintainance cost can be decreased further, if more spare parts could be manufacture locally; and
- locally-available spare parts would serve also to extend service life by avoiding obsolescence when a foreign equipment manufacturer changes models and ceases spare part manufacture.

E. FACTORS TENDING TO PROLONG SERVICE LIFE

The administrative and technical changes which are currently being implemented with respect to establishing a Mechanical Services Division in the Bureau of Public Highways, offer a potential to cancel the detrimental service-life effects of past practices. As already noted, they are:

- the establishment of Regional Mechanical Depots and Area Shops which are to be properly equipped and organized for the necessary servicing of equipment and the training of operators and mechanics. It would then appear that the limiting service-life factors cited above will be corrected, except for the factors referring to the standardization of equipment makes and to the purchase of equipment whose manufacturers are not adequately represented in the Philippines; and
- the institution in these shops of a comprehensive system of preventive maintenance designed to detect problems in the equipment operation before they become serious. Incidentally, it would then appear that

the demand for certain spare parts could be reduced.

The PTAP has identified further opportunities for beneficial change which can produce savings in the cost of the preventive maintenance work and also increase the effectiveness of preventive maintenance in prolonging equipment service life.

1. Technological Practices in Preventive Maintenance

Two specific technological practices are available which have not yet been considered in the course of the efforts to reorganize the mechanical services functions of the BPH. They are:

- the technique of analyzing periodically a sample of lubricating oil taken from a given equipment unit to identify the trace elements present and their quantities; and then evaluating the accumulated data to alert the repair shop to probable locations of deterioration, and at the same time to specify the urgency for attention; and
- techniques based on non-destructive testing using radiation, ultrasonic, and electromagnetic analyses, and liquid-dye penetration phenomena, which can detect the extent to which metal fatigue failure has already occured in a given equipment unit. Then, the replacements needed can be determined before major damage from such failure occurs in the unit.

A review of the literature describing the details of these techniques is presented in Appendix H. The lube-oil analysis technique was recently (September, 1972) reported in the Magazine "Philippine Architecture, Engineering and Construction Record".

According to the report, a recent development has been a full-scale dealer program to analyze oil for metal parts wear. Caterpillar claims to be the first equipment manufacturer to offer this program. The program is based on measuring the quantities of minute particles of wear metals which pass through the filter and remain suspended in the oil. The measurement is done with an atomic absorption spectrophotometer, which can detect and measure a fraction of one part per million. The finding, which shows wear metal concentrations, is measured against norms developed by the Caterpillar people for various kinds of equipment under a variety of working conditions.

Their research showed, for example, that iron in the oil generally signals oil pump wear, shaft wear, and in engines, liner wear. Chromium represents wear of piston rings, bearings, and in some instances, valve stems. Copper means thrust bearing wear, transmission or steering disc wear. Aluminum indicates piston or bearing wear. The oil samples provide readings which will fall into one of four categories - normal, reportable (you should be alert), bad (needs correction, schedule machine for repair at a convenient time), and urgent (take machine out of operation at once and repair immediately).

While even Caterpillar admits that atomic absorption spectrophotometer testing of this kind is not a magic cure to detecting all vehicle operating problems, results have shown that analyzing oil for wear metals promises to be a valuable maintenance tool for the future, since about 50% of all machine failures are due to abnormal wear. Being alert to wear in time can help operators take corrective action before failures occur. It is clear, especially since the technique appears to be more widespread than the report above attributed to Caterpillar indicates, that the technique merits consideration by the Regional Depots and Shops for a number of reasons:

- the initial installation is simple and inexpensive to operate;
- an atomic absorption spectrophotometer installation already exists in the Philippines at the Metals Industry Research and Development Centre in Bicutan (Las Piñas), Rizal. This Centre is owned and operated by a government agency, the Board of Investments;
- another system of similar scope seems to be available (Appendix H, page H-2) operated by the Mobil Oil Corporation at Pandacan (Manila). The system is called Engine Maintenance through Progressive Analysis (EM/PA); and
- there was unanimous opinion in favor of trying the technique from the participants of the meetings conducted by the PTAP during its field travels.

With respect to the non-destructive testing techniques (Appendix H, Tables H-1a and H-1b), further investigation is desirable on behalf of the Regional Depots and Shops to identify the techniques meriting installation as part of normal preventive maintenance practices.

2. Personnel Practices in Preventive Maintenance

Two prospective administrative factors warrant consideration in the view of the PTAP for introduction to the Regional Depots. They could serve to reduce the cost of preventive maintenance, and also prolong equipment service life through greater care in the operation:

- providing the services of the equipment operator as part of the agreement for the rental of an equipment unit as an alternative to the supply of these services by the district engineers, and
- motivating the operators and mechanics by employing them on permanent rather than on daily staff.

With respect to the responsibility for the services of the equipment operators, each alternative, namely supply by the depot or supply by the district engineer, has merit. The district engineer is justified to believe that, if the operator feels responsible to him, the engineer will obtain a greater production from the equipment unit, The depot equipment engineer is justified to believe that, if the operator feels responsible to him, he will find that better care has been taken to avoid abuse of the equipment in the field. This divergent set of viewpoints, as far as the PTAP is aware, has not yet been resolved. The PTAP believes that some basis could be identified that represents a balance between acceptable productivity levels of equipment and avoidance of unwarranted maintenance for the equipment, which overall is in the best interests of the BPH. The need is to find such a compromise.

With respect to the motivation of operators and mechanics, the factors involved are complex. Perhaps the most important and obvious factor is pay scale. As already noted, the BPH has been somewhat of a training school for operators and mechanics, who, as soon as they have adequate experience, leave the service for more attractive positions in the private sector, or to go overseas. One comment by the private sector at the PTAP seminar stated that the BPH pays an operator 10 pesos per day and gives him the responsibility for caring for 500,000 pesos worth of equipment.

Another important and obvious factor is probably instilling a feeling of job security in the personnel charged with operation and maintenance. The PTAP noted during its travels that daily paid workers remain in this status for as long as ten years without benefits before they are discharged.

A number of subtle factors are probably important in raising levels of motivation in personnel. Among these are:

- Self-preservation - fear of injury requires attention to be given to providing safe working conditions.
- Support - provide the satisfaction of a completed job by having spare parts on hand.
- Recognition - provide recognition of superior performance through awards, whether monetary or otherwise.
- Cultural Traits - take advantage of the natural Filipino trait within small groups of loyalty to the leader, through emphasizing appropriate/team efforts.
- Delegation of Responsibility - delegate the corresponding authority clearly, so that the worker can perform effectively.
- Pride - provide an environment that recognizes that individuals take pride in their work (e.g attaching an operator to a given machine to which he can give a name if he desires).
- Rivalry - Promote friendly competition among groups or teams.

Upon completion of the reorganization of the BPH mechanical services activities, consideration should be given to the motivational factors identified.

3. Local Manufacture of Spare Parts

Local manufacture of spare parts can serve to reduce costs in specific ways, such as:

- as already noted, premature obsolescence of a BPH equipment unit may be avoided when a foreign manufacturer ceases production of spare parts, or abandons its service facilities in the country;
- expenditures in foreign exchange can be reduced; and
- employment opportunities for local personnel can be generated.

Also as already noted, considerable capability exists in the Philippines in spare part manufacture (Appendix F). The Metals Industry Research and Development Centre of the Board of Investments can be an important factor in developing the capability of the industry to supply a complete line

of spare parts. This Centre already has such a program planned, although it is not yet funded. It has close ties with the private metal-working sector in terms of knowing its capability and the characteristics of the physical facilities. It serves as a demonstration center primarily for new metal product development. Finally, it has a staff familiar with metal working problems which could train personnel for employment in the factories of the metal working sector. The indications of the market which the BPH could offer to help support the local manufacture of spare parts are presented in Table 14.

It is noteworthy that the amounts shown in this table (Item 2) constitute only the value of parts issued by the Spare Parts Depot, and do not reflect the spare parts acquired by the various District/City and Project Engineers. The future road construction program, the corresponding future acquisitions of new equipment units, and the new emphasis on preventive maintenance should act to increase the indications in Table 14 of the demand generated for spare parts by the BPH operations.

Some parts in fact are already locally manufactured. Undercarriage parts and some engine parts are examples. Whether these are being made of identical alloys or to the precision of the original equipment manufacture, of for as low a cost, may not be the central issue for the reason of the foreign exchange factor involved. It may be desirable to accumulate experiences in the service life of a local spare part and to compare this with the service life, if the original equipment manufacturer's part were used. The results can then serve to correct the selection of the materials and to redefine the manufacturing precision. A careful program of local purchase of spare parts permitting series manufacture can improve the cost.

Adequate foundry capacity is available which depends, of course, on internal and on locally purchased ferrous scrap. An adequate quantity and quality of machining capability is available with a few exceptions, such as the ability to generate (and inspect) hypoid gearing. The machinery installed is generally not the newest in age or design, but it can be considered appropriate for low-volume manufacture. Forging and heat-treating capacity is scattered in many plants and is probably adequate for most of the smaller parts. Crankshafts and bulldozer structural parts would be too large for local forging.

TABLE 14

SPARE PARTS CONSUMPTION BY THE BPH

1. Between FY 1953 and December 1972

a. Total Receipts	Million Pesos
Development Loan Fund Parts	₱ 27.79
Locally Purchased	18.52
Deferred Payment	13.50
Reparations	14.07
Trust/Reimbursable Fund	8.70
Philippine-Japan Highway Loan	38.35
Total	₱ 120.93

b. Issuance at the end of December, 1972	
Development Loan Fund Parts	₱ 25.31
Locally Purchased	14.92
Deferred Payment	4.95
Reparations	6.24
Trust/Reimbursable Fund	1.60
Philippine-Japan Highway Loan	7.73
Total	₱ 60.75

c. Net Inventory, Total	₱ 60.18

2. For Selected Equipment Units between October 1971 and October 1972

Tractor, Crawler	Total Value
(a) 180 HP Class	₱ 201,500
(b) 120 HP Class	582,000
Dump Truck	
(a) 6 cu. yd.	206,000
(b) 4-5 cu. yd.	301,000
Total	₱1,290,500

Source: Records of the BPH Spare Parts Depot, Manila

Many critical parts are non-metallic, or are metal/non-metal composites. O-rings, gaskets, oil seals, air and oil filters (these may be considered consumables rather than spare parts) and the like can apparently be produced in adequate quantity and quality by local industry. Such production, as in the case of metal parts, depends on a willingness to pay a tooling premium in the unit product cost until production volume reaches competitive levels.

F. APPLICATION TO REGIONAL EQUIPMENT DEPOTS

The PTAP believes that significant opportunity exists to reduce costs in the operation of heavy construction equipment through the introduction of specific changes in the operations of the regional equipment depots beyond those so far envisioned in the current implementation of the results of the work of the Kampsax-Berger. Specifically, the changes involve reducing the costs of the comprehensive preventive maintenance program now being installed in the depots, and attempting to assure more effective results in prolonging service life. The PTAP has identified four distinct sets of actions which can be responsive to these goals.

1. A Rational Definition of Equipment Service Life

A rational method for defining equipment service life is required for use (a) within the Mechanical Services Division of the BPH to enable it to determine when to recommend that a given equipment unit should be disposed because its service life has reached its end, and (b) within the planning and funding agencies of the DPWTC and the Government to enable them to determine whether or not a replacement unit is warranted from the broader point of view of government budgeting demands and from knowledge of the forthcoming road construction program.

A technical description of one possible method has already been described above. The method eventually selected however, should operate as follows:

- all financial cost records and all technical details of preventive and other maintenance performed on any equipment unit of the two types considered are to be supplied the area to the regional shops, and then to the central office of the Mechanical Services Division;
- the data in the records are to be processed during each interval of equipment operation (for example, after each 2000 hours of operation)

to calculate the appropriate financial cost function during that period in order to compare it with the criterion adopted in the method for measuring end of the service life;

- when the criterion suggests that the service life of a particular equipment unit has ended, the Mechanical Services Division is to recommend its replacement to the management of the BPH, who, in turn, is to determine whether the needs of the current construction program warrant the replacement;
- when the BPH determines that a replacement is warranted, it is to recommend such a replacement in the budget plans for the forthcoming fiscal year by forwarding, in its budget request, the complete details of the financial cost analysis and break-downs of costs allocated to those paid in local currency, those paid in foreign exchange, and those paid for the employment of labor;
- the budget planners are then to decide from the national economic costs of the current maintenance on the particular equipment unit, measured against the national economic costs of the replacement of the unit, whether (a) to approve the replacement, or (b) to defer consideration of replacement until the request is raised again such as by the submission of new data after the next interval of operation;
- in the event the decision is in favor of (b) not to replace, appropriate adjustments are to be made in the budget for the BPH in order to accommodate the higher financial cost of maintaining that particular equipment unit during the next interval of operation; and
- if the decision is (a) to replace, the purchasing procedure is to take account of the accumulated cost experiences from the unit being replacedin order to select the replacement in the best interests of the BPH when comparing alternative brands during the procurement negotiations.

2. Introduction of Non-Destructive Testing Technology

Appropriate non-destructive testing technology now available in advanced industrial nations, should be transferred for use in the regional mechanical service depots of the BPH as an aid to achieving a more-effective

preventive maintenance program. Details of this technology have been discussed above. The elements to be incorporated in the transfer should be the following:

- the identification of the technologies which can fit into the operations of the mechanical service depots, area shops, and mobile shops;
- the identification of the methods for operation and the training needed by the personnel involved in the operations;
- an assessment for each method selected of the potential to reduce the cost of preventive maintenance practices in the various repair shops; and
- an estimate for each method identified of the cost of its installation and operation.

3. Improvement in Personnel Practices

Personnel practices in the Bureau of Public Highways which are related to the operation and maintenance of its equipment, should be reviewed in order to identify those changes which can serve to motivate (a) operators to take conscientious and competent care of the equipment during its operation and (b) mechanics to perform conscientious and competent maintenance work. The elements to be considered in the review should include the following:

- wage and salary scales (including the benefits conventionally paid) in the public and private sectors of the country;
- relating a particular operator to a particular equipment unit to generate a pride in the operator from effective operation and avoidance of abuse; and
- providing more-intensive on-the-job training than is presently envisioned, which can lead to promotion to positions of increased responsibility.

4. Local Manufacture of Spare Parts

The BPH should offer its cooperation to the Board of Investments in connection with the desire of the Board to encourage greater local manufacture of spare parts through the activities of the Metal Industry Research

and Development Centre. The cooperation should incorporate the following elements:

- compile from its maintenance records, the spare part items that are consumed, their delivered costs, the details of their design, the specifications for the materials of fabrication, and the dimensional tolerances; and compile these in a manner that both describes the market offered to local manufacturers by the BPH and the technical requirements of the parts for use by the MIRDC;
- explore the feasibility of modifying component designs, without detriment to the operation of the machines, to enable local manufacture instead of import. For example, the use of an alternative design of diesel-engine turbocharger, could be considered;
- formulate a purchasing policy for locally-manufactured spare parts, whenever these are offered, which does not (a) burden the manufacturer with extraordinary working-capital problems because payments may be delayed, and (b) burden the BPH with spare parts of inadequate quality with respect to the material of fabrication, the design, and the dimensional tolerances; and
- identify the role of the MIRDC in the control of the quality of locally-manufactured spare parts.

VI IMPROVING THE DISTRIBUTION OF CEMENT

The utilization of cement is an important factor in road and highway construction in the country. In addition to its conventional uses, portland cement is extensively used in the road pavement. The extent of cement use for the future has been estimated in Table 9 as 5.1-million metric tons over the period FY-1973 to FY 1980 inclusive. The geographical distribution of this use throughout the country by BPH regions is estimated in Table 10.

Since 1936 when the first portland-cement pavement was laid down, and since the 1950's when additional installations began to be made, government policy has been to emphasizethis pavement type deliberately. As the result, the proportion of new road construction, which will be portland cement-concrete paved, has been increasing and will continue to increase in the future. The policy has been reaffirmed as a result of the damages experienced during the 1972 floods, in view of the proven ability of cement-concrete pavements to withstand water damage as compared with that for asphalt pavements.

The purpose of this chapter is to explore the potential to reduce the in-place cost of cement to the BPH through identifying opportunities to improve the distribution of cement between the factory gate and the job site.

A. BACKGROUND

The current production capability of the Philippine Cement industry is shown in Table 15. At the present, if the industry operates at full capacity, about 7.1-million metric tons per year can be produced. Table 15 also shows the allocation of this capability to the geographical regions of the BPH. Recent actual production of cement by the Philippine industry is shown in Table 16. From this table (in which productions figures for 1972 are shown only for the January-July period), it can be noted that the industry is currently producing only at about 45 percent of capacity.

Table 17 shows a projection of future domestic demand in the country throughout 1981 at two rates of growth, namely an optimistic one at 5 percent per year and a pessimistic one at 2.2 percent per year, based on a methodology used by the Development Bank of the Philippines.

TABLE 15

THE PORTLAND-CEMENT PRODUCTION FACILITIES OF THE PHILIPPINES (SEPTEMBER 1972)

Region	Name of Plant	Location	Installed Capacity Metric Tons/Year
I	Bacnotan Consolidated Industries, Inc.	Bacnotan, La Union	256,000
		Regional Total	256,000
II	-	Regional Total	0
III	Northern Cement Corp.	Sison, Pangasinan	640,000
	Luzon Cement Corp.	San Ildefonso, Bulacan	154,000
	Hi-Cement Corporation	Norzagaray, Bulacan	385,000
	Republic Cement Corp.	Norzagaray, Bulacan	640,000
	Continental Cement Corp.	Norzagaray, Bulacan	358,000
		Regional Total	2,177,000
IV	Rizal Cement Company, Inc.	Binañgonan, Rizal	358,000
	Marinduque Mining and Industrial Corporation	Antipolo, Rizal	770,000
	Filipinas Cement Corp.	Teresa, Rizal	565,000
	Midland Cement Corp.	Tanay, Rizal	450,000
	Fortune Cement Corp.	Taysan, Batangas	385,000
		Regional Total	2,528,000
V	-	Regional Total	0
VI	Philippine Portland Cement Co.	Guimaras Is., Iloilo	30,700
		Regional Total	30,700
VII	Apo Cement Company	Naga, Cebu	154,000
	Universal Cement Co.	Danao City, Cebu	640,000
		Regional Total	794,000
VIII	-	Regional Total	0
IX	-	Regional Total	0
X	Pacific Cement Co.	Surigao del Norte	180,000
	Mindanao Portland Cement Corp.	Iligan City	154,000
	Iligan Cement Corp.	Iligan City	358,000
	Floro Cement Corp.	Lugait, Misamis Oriental	450,000
		Regional Total	1,142,000
XI	Bacnotan Consolidated Industries, Inc.	Davao City	128,000
		Regional Total	128,000
		NATIONAL TOTAL - - -	7,055,000

Source: Cement Association of the Philippines.

TABLE 16

RECENT ANNUAL PRODUCTION OF PORTLAND CEMENT BY THE PHILIPPINE INDUSTRY

(In Thousand Metric Tons)

Name of Plant	1965	1966	1967	1968	1969	1970	1971	1972 d/
Bacnotan 1 & 2	273	303	290	303	418	375	260	141
Hi-Cement	-	-	-	128	324	196	277	158
Republic	380	388	341	469	486	409	380	107
Luzon	-	-	-	4	102	107	94	64
Rizal	345	341	337	316	290	235	205	115
Filipinas	273	226	409	431	384	196	256	158
Marinduque	-	-	239	316	328	550	422	264
Fortune	-	-	-	-	-	30	294	154
Phil. Portland a/	21	17	21	17	21	9	-	9
Universal	111	192	200	226	226	200	243	145
Apocemco	119	132	119	124	77	26	13	60
Mindanao	--	81	94	149	128	81	119	55
Pacific	--	-	68	149	136	55	60	43
Iligan	--	-	-	-	-	-	94	72
Floro	--	-	-	-	-	-	9	-
Northern	--	-	-	-	-	-	563	68
TOTAL b/ & c/	1,522	1,680	2,118	2,632	2,920	2,469	3,289	1,613

a/ Stopped operation since October, 1970, resumed January, 1972.

b/ Totals may not add up exactly due to rounding.

c/ Data for Northern in 1970 and 1971 not available. Figures used for 1971 is the sum of domestic and export sales.

d/ Production from January through July only.

SOURCE: Cement Association of the Philippines.

TABLE 17

PROJECTED PORTLAND-CEMENT DEMAND IN THE PHILIPPINES (1973-1981)

(In Million Metric Tons)

Year	High Estimate a/	Percent of Capacity	Low Estimate b/	Percent of Capacity
1973	2.98	42.3	2.52	35.9
1974	3.20	45.4	2.63	37.4
1975	3.41	48.6	2.74	38.9
1976	3.61	51.5	2.83	40.2
1977	3.84	54.8	2.93	41.7
1978	4.06	58.0	3.02	42.9
1979	4.30	61.3	3.10	44.1
1980	4.53	64.7	3.19	45.4
1981	4.95	67.9	3.27	46.4
Average Rate of Increase	5%/year		2.2%/year	

a/ Derived from linear projections of cement value as a percentage of gross construction expenditures.

b/ Based on correlation of cement consumption (quantity) with construction expenditures, also using linear projections.

SOURCE: Development Bank of the Philippines, Economic Research Unit, Memorandum 27 September 1972

From either projection, it appears that a condition of overcapacity in the industry will prevail for the foreseable future. Currently, efforts are underway to develop foreign markets for the excess production capability. It is unlikely that the projections in Table 17 reflect the future BPH consumption forecast in Table 9, and it would seem that the projection labeled "High Estimates" in Table 17 may actually turn out to be low estimates.

Thus, enough cement production capacity is now installed to supply for at least a decade more than the national cement requirements. In fact, the cement industry is faced with the problem of how to increase the present low-utilization of capacity, because the growth of domestic demand has lagged far behind that of the growth of supply capability. Local producers have tried to solve the problem by working on both the supply and the demand aspects.

On the supply side, the industry has opted for a policy of "containment". Thus, firms have produced only so much and no more in order to limit supply. Accordingly, no pressures resulted to cause prices to go down. On the contrary, this limitation on supply enabled producers to raise prices. It was feasible for the producers to establish such a control of the domestic supply of cement and its price because almost all of the firms in the industry literally faced the problem of survival. Banding to work together to form, in effect, a cartel was the only viable alternative.

On the demand side, it appeared unlikely that the industry could promote means to increase domestic demand to the desired level. Hence, in this area, cement producers, presenting a similar unified front, turned their attention towards the export market. As the result, the companies have been able to obtain better terms and prices than was the case as recently as three years ago, when attention first began to be paid to the potential of exports.

Although export prospects for the next few years appear to be good (and obviously should be taken advantage of), most Asian importers, after five years at the outside will no doubt have set up their own cement manufacturing facilities and accordingly will have drastically reduced their imports. Over the long run therefore, the industry will have to depend primarily on the domestic market. In this respect, the large demand indicated for the BPH in Table 9 may be a significant factor.

The basic source of finance for the construction of the industry has largely been the loans made by the Development Bank of the Philippines (DBP). The poor market conditions of the industry has led to numerous defaults in the repayment installments, and to a number of attempts by the government to assure repayment of the loans. For example, until early this year payments for government purchases of cement were made directly to the DBP.

On 11 January 1973, a presidential decree (No. 94) established the Cement Industry Authority (CIA), composed of the Chairman of the Board of Investment as the chairman, and the heads of the Central Bank, the Department of Finance, the Department of Trade and Tourism, and the Development Bank of the Philippines as members (or their representatives). The CIA is to exist for a period of three years.

With respect to serving the domestic demand for cement, the decree established six specific functions for the CIA to perform. These are the following:

- Establish distribution areas and enforce sales quotas, and regulate such marketing activities as the CIA may deem necessary to allocate in an equitable, orderly and efficient manner the private domestic and the government demand among all the cement companies in order to maintain the stability of the local market;
- In conjunction with appropriate government agencies, advise the Price Control Council in establishing and enforcing uniform and reasonable selling prices of cement at the various levels in the distribution system and within given market areas, taking into account costs of production, transportation, handling and warehousing;
- Conduct periodic inspections of all plants to test product quality and bag weights; to check inventories, production, sales and delivery records; and to verify compliance with rules that the CIA may promulgate in connection with the domestic marketing of cement;
- Impose appropriate penalties on cement companies, their distributors and dealers for violation of any rule, quota or guideline established by the CIA;

- Establish a reporting system and maintain statistical records on the production, distribution and consumption of cement by geographic areas to serve as the basis for the efficient and economic distribution of cement; and
- Negotiate and enter into contracts for the bulk purchase of materials and supplies common to all cement plants such as kraft paper, grinding balls, and silica; and maintain inventories of such materials where necessary to reduce the operating costs of the industry.

Item 5 of the functions listed above, namely, the identification of efficient and economic distribution of cement, should be of interest to the BPH because of the volume of cement it may consume in the future, which must be distributed to widely dispersed and remote areas of the country.

The PTAP has identified two opportunities to reduce the cost of cement in place, which are based on more efficient and economic distribution. These are:

- the basic distribution of cement in bulk; and
- the decentralization of the factory depots.

B. BULK DISTRIBUTION

The Bureau of Public Highways presently consumes cement almost entirely in bags. For the cement consumption anticipated, in Table 9, the total of the individual costs attributable to the use of bags is about P110-million, or about 22 percent of the value of the cement. This estimate is developed in Table 18. Also shown in this table is the allocation of the total cost among the individual cost factors. The major cost item is the cost of the bags at about 63 percent of the total cost of handling in bags.

Some cement is already being distributed in bulk in the greater Manila area by Delgado Brothers, Inc., who work in conjunction with the Republic Cement Corporation. The characteristics of its operation seem to be the following:

- A fleet of about 15 road cement-tankers are operated, whose capacity ranges from 13 to 20 metric tons each; and

TABLE 18

ESTIMATED COSTS ATTRIBUTABLE TO HANDLING CEMENT IN BAGS

Item	Cost ₱/Ton	Total Cost (FY 1973-80) Million ₱
Basic Cost of Bags (4 ply)	14	71.40
Net Cost of Breakage (1)	1.5	7.65
Handling		
Loading	1.0	5.10
Unloading	1.0	5.10
Pilferage (2)	0.5	2.55
Cost of Bagging (3)	3.7	18.87
Total (8 years)		110.67
Average yearly		13.83

Notes: (1) 3% of quantity handled less 50% recovery of contents, i.e. 1-½% of quantity handled.

(2) Taken as ½ of 1%

(3) Exclusive of bag cost, taken as 25% of the bag cost.

Source: PTAP Estimates

- Republic Cement reduces the bag price by 30 centavos when cement is bought in bulk, but at the same time charges ₱1,000 for the transport and erection of a bulk storage tank of 1,200 to 1,500 bag capacity equivalent; and 10 centavos per bag equivalent for the use of the storage tank.

The Fortune Cement Corporation operates bulk carriers to deliver cement to a sister company located about 70 kilometers distant by road, for use in the production of cement concrete mix. The carriers were imported from Japan at a cost of about ₱230,000 each. Each has a net capacity of 14 metric tons and is provided with an air compressor for discharging the cement pneumatically. Loading time by gravity is about 15 minutes. Discharge time is about 5 minutes. Transport costs for bulk delivery are about 25% less than for bag delivery, despite the fact that the transport equipment returns empty after the delivery of the cement.

Filipinas and Hi Cement also distribute cement in bulk in their own equipment. The Highway District Engineer's Office in Bulacan is receiving bulk cement in its operations. Some cement in Davao City is being distributed in bulk. Most recently (April 1973) a major cement producer in Mindanao has expressed an interest in the concept.

If the system for handling cement were to be changed from emphasis largely on bags to emphasis largely on bulk, the costs developed in Table 18 could be largely eliminated. But, new costs would arise, namely, the following:

- the cost of amortizing the capital expenditures incurred to install bulk-handling equipment and facilities. These facilities would include specially designed road cement-tankers, and the addition of storage tanks and compressed-air installation at central concrete batching plants. A typical batching plant installation currently in use with bagged cement is shown in Figure 5.
- labor associated with operating this equipment; and
- the difference in the running cost of the transport.

Not all cement consumption is amenable to bulk handling. In general, when cement concrete is mixed in one or two bagger mixers, bagged cement is appropriate. Bulk cement would be appropriate when cement concrete is

mixed in central batching plants. Thus, all of the savings indicated in Table 18 cannot be realized. It would appear reasonable, however, to presume that a large-scale conversion to handling cement in bulk could occur in the Bureau's operating practices to the extent of 75% of the quantity forecast as consumed through FY 1980. It also appears that investment in new facilities will be nominal so that the total saving in the cost of cement approach about P80-million over the period FY 1973 through FY 1980.

The problems to be solved in such a conversion appear to be the following:

- although the transportation, handling, and use of cement in bulk is technically feasible and has in fact already been introduced to the Greater Manila area, providing an opportunity for Bureau of Public Highways personnel to become experienced in the technique for the large scale introduction of the method;
- selecting specific road construction projects which can be supplied with cement in bulk, so that these could serve as pilot projects to develop experience in the Bureau's personnel; and
- providing new investment to convert cement-concrete batching equipment to accept bulk-cement by installing the additional silos and accessory equipment required, and by purchasing truck trailers designed for transporting bulk cement in tanks and provided with piping for unloading by compressed air.

With respect to selecting suitable pilot road-construction projects, it appears the candidates are the following:

- the Digos-Cotabato Road in Region XI which is now under construction with Philippine Rock Products Inc. as general contractor. The cement source for this road is the Bacnotan plant north of Davao City. Philrock has already used bulk transport methods in the Greater Manila Area.
- the General Santos-Cotabato City road in Region XI which is now in the stage of contract negotiation.
- Iligan City-Cagayan de Oro-Butuan City road which is now in the detailed design stage. The cement sources for this road are the two plants in Iligan City, and one in Misamis Oriental, namely the Floro Cement, the Mindanao Cement, and the Iligan Cement.

- Batangas City-Lobo Road, Batangas City section, which will serve primarily the Fortune Cement Company which must use this road for access to all its markets. The PTAP understands that the cement plant management has already offered to assist in the construction of this road by supplying cement-concrete components free of charge.
- Layac-Mariveles Superhighway (Layac-Balanga Section) now under construction by Construction and Development Corporation of the Philippines.

C. DECENTRALIZATION OF DEPOTS

One result of the intensive travels of the PTAP throughout the country has been the realization that cement prices may be unnecessarily high in certain areas of the country. One example is the Bicol area where the local price is ₱6.00 to ₱6.25 per bag as compared to factory price of approximately ₱4.00. The reason given is the high cost of land transportation between cement plants in Central Luzon and the Bicol afea.

Another example appears to be Bacolod City in the Visayas which receives cement only by water transport from nearby cement plants, such as at Cebu City. High costs seem to arise from an ineffective use of barges. An example of effective use would be the shuttling of barges back and forth between cement plant and depot on a fixed schedule, but this change requires the extension of the factory operations to distant depots, or a decentralization of the factory depots. In a discussion with the general manager of one cement plant, an opinion was generated that the savings per bag may be as much as ₱0.25. This saving could arise on the basis that transport of cement in the barge occurs in bulk and small bagging plants are located at the decentralized depots for bagging to local demands. Bulk cement could also be sold at these locations.

Thus, it appears that significant reductions in the delivered cost of cement may be aahieved by making better utilization of low-cost water transport when a major island in the country does not have a cement manufacturing plant located on it, or when distances of transport by land are large. Achieving such reductions would require that

- storage depots for bulk cement be located at strategic market centers operated by the cement manufacturer as an extension to his factory;

- the depots be supplied constantly and consistently through water transport in barges programmed to make maximum use of the transport equipment;
- the cement be transported in bulk; and
- the depots be provided with bagging machines for the sales made in bags.

Specifically, the transport of cement to alleviate high transport costs should occur in bulk and in barges shuttling back and forth between cement factory and island depot, travelling in fixed pattern all the year around and probably serving a number of cement depots. Efficient use of water transport equipment would distribute the fixed charges from the investment in the barges and tugs over many more tons of cement, and the bulk-transport mode would reduce the idle time of the transport equipment because of fast loading and unloading. It would be necessary to install bagging machines at the depots to serve the local markets for bagged cement. The most important new facet introduced into conventional cement marketing would be the "decentralization" of the factory to outlying depots, where the sales of cement would actually occur.

In effect, cement would then be marketed like petroleum products which are sold from decentralized wholesale depots, or also like beer. Recently, the San Miguel Corporation released information on a new distribution system for their bottled beer product, which should now be in operation. It described new barge and tug equipment. The unusual feature for the Philippines is that the tug will push instead of pull, and in so doing it will be able to control two barges which are lashed together to form a single unit, much better than if it were to pull the barges with a tow line in the more conventional manner. The speed in a push system can be greater than for a pull system, so that the present 72 hours, or more, from Mandaue to Zamboanga City trip can be cut to less than half, about 31 hours. Thus the equipment can double its transport capability because it travels twice as fast. Furthermore, the maneuverability while docking is increased, so that time spent berthing and departing can be reduced.

The PTAP has identified locations where depots operated as extensions to the cement factory in such a manner can act to reduce cement costs.

They are

- Pasacao in Camarines Sur,
- Legaspi in Albay,
- Bacolod City in Negros Occidental,
- Zamboanga City in Zamboanga del Sur, and
- Tacloban City in Leyte

The reduction in the case of a Bacolod City location is estimated, as already mentioned, to be about 25 centavos per bag equivalent. The indications for the Legaspi City and Pasacao locations are for even greater savings.

The scheme is technically feasible, but it appears financially difficult for the cement industry at this time to undertake the investment necessary in new facilities. Finally, the concept merits the attention of the Cement Industry Authority as the potential implementing agency. One problem which would arise is the manner for distributing equally the savings among the manufacturer, the transporter, and the consumer.

D. APPLICATION TO BPH OPERATIONS

Thus, two specific actions should be taken with respect to achieving construction cost reductions through reducing the cost of cement in place. The first action should deal with conversion to bulk handling from cement factory to those road construction projects where portland-cement concrete is mixed in centralized batching plants. The second should deal with encouraging the decentralization of factory depots where the cost of decentralization is justified by savings in transportation costs which result.

For the first action, the Bureau of Public Highways should select specific road construction projects which it would supply with cement in bulk, and designate them as pilot projects to develop experience in the Bureau's personnel. Candidates for selection have already been mentioned above.

The pilot projects should be organized such that the following elements are incorporated:

- KeyBPH personnel are given the opportunity to study the problems and observe the solutions as they become evident from the operations of the pilot projects;

- the Construction Division is given the responsibility and the necessary funds for the implementation; and
- the results are evaluated and recommendations formulated so that a detailed plan becomes available to guide the BPH in the use of bulk handling of cement for cost savings in the future road construction program.

For the second action, the Bureau through official channels, should call the attention of the Cement Industry Authority to the results of the PTAP work that are relevant to the decentralization of factory depots. Furthermore, the BPH should encourage actions by the Cement Industry Authority toward this end, and should cooperate with them in the implementation as far as the Bureau's interests are affected.

VII INCREASING THE UTILIZATION OF COMPUTERS

A computer is a sophisticated electronic tool capable of rapidly performing computations and/or managing the collection and evaluation of large masses of data. Its proper utilization can considerably ease the burden of long, involved engineering computations, especially where there are repetitive operations. With skill in computer methods, engineering and technical personnel, having been freed of tedious and time consuming manual methods of computation, can devote more time to the actual engineering and analytical work involved in the exploration of alternative designs for a given project. Experienced personnel would be freed to exercise judgement and select those alternatives which provide opportunities to reduce costs without compromising the quality of the finished project.

The Bureau of Public Highways has already begun to employ computers in its operations, and in fact operates a small IBM 1440 installation at its headquarters. However, the work program for this installation is aimed primarily at facilitating the accounting work of the BPH whether this involves payroll preparation or controlling the inventory of spare parts for highway equipment.

The PTAP, in view of such an existing capability in the BPH, explored the opportunities to utilize computers as a means for reducing construction costs. Specifically, this exploration considered:

- the development of a computer program to aid in the decision-making process in selecting the type of pavement to use in a new road construction project; and
- prospective applications of computers in the current operations of the Bureau of Public Highways as a means of reducing costs.

A. AVAILABLE COMPUTER FACILITIES

The Electronic Data-Processing Section, a service section under the Administrative Division of the BPH, is charged with the responsibility of undertaking the processing and preparation of statistical and accounting reports for various offices of the Bureau. This office is equipped as described in Table 19. The machine configuration is inadequately sized to handle the FORTRAN language. Personnel positions which have been established in the Electronic Data-Processing Section are as follows:

TABLE 19

COMPUTER FACILITIES IN THE BPH

1. An IBM 1440 Electronic Data Processing System with 8,000 position (8K) of core storage composed of the following machine configurations:

QTY.	TYPE	MODEL	DESCRIPTION
1	1441	A3	Processing Unit
1		5561	Printer Attachment
1		2260	Console Attachment
1		3321	Disk Storage Control
1		4631	Indexing and Store Additional Extra Storage
1		5275	Multiply Divide
1		3281	Direct Seek
1		6393	Scan Disk
1		7600	Sense Switches
1	1442	2	Card Read/Punch
1		1632	Card Punch Adapter
1	1443	2	Printer
1		5567	Printer Control
1		5559	Additional Print
1		5585	Print Storage
1	1447	2	Console w/Typewriter
1	1311	1	Disk Storage Drive
1		2	Disk Storage Drive
16			Disk Packs

2. The following auxilliary machines to support the System:

1	026	1	Card Punch
1	024	1	Card Punch
3	056	1	Card Verifiers
1	083	1	Sorter
1	077	1	Collator
1	557	1	Interpreter

Chief of Section	1
Assistant Chief of Section	1
Table Equipment Operator II	1
Table Equipment Operators I	2
Supervising Key Punch Operator	1
Key Punch Operators	7
Senior Coder-Verifier	1
Coder-Verifiers	7

The Bureau has available to it outside computer facilities as follows:

- At the Bureau of Telecommunications (BUTEL) of the DPWTC. This installation is located in Quezon City, and comprises an IBM 1130 (12K) system with complete accessories, capable of handling Fortran. It is currently available to BPH for use on weekends. It is being used by the Bureau's Consultants KAMPSAX/Berger, at a rental rate of about P150 per hour.

- At Commercial Computer Service Centers. The most noteworthy is the IBM Service Center in Makati which is equipped with an IBM 360 system of broad capability. It is available at a rental rate of about P1000 per hour. The PTAP obtained free trial use of this computer installation during its work.

B. DEVELOPMENT OF A PAVEMENT-TYPE EVALUATOR.

As already noted, the current BPH policy, once the decision is taken to pave a road, is to prefer the installation of portland cement-concrete pavement to asphalt pavements. However, this policy seems to be implemented somewhat unevenly. Thus, the effects of the policy may be less useful than intended. Present implementation occurs more or less in the following manner:

- for road-construction projects financed by loans from foreign development banks, a foreign consultant undertakes the feasibility study, and in the course of that study establishes the type of pavement to be installed. An inspection of four recent consultant reports shows that the depth of analysis is variable, the spectrum ranging from a detailed analysis to an apparently arbitrary selection. The Bureau of Public Highways may disagree with the consultant's selection of

pavement type, in which case the financing bank tends to have an open mind on the subject of resolving the disagreement;

- for road-construction projects financed by the Philippine Japanese Highway Loan, or by the new Japanese Commodity Loan, the Bureau of Public Highways is free to select the type of road pavement as it sees fit; and

- the technical-economic criteria used by the BPH to select the pavement type seem to be qualitatively applied. They involve the consideration of the probability of the road being flooded, the fact that the cement industry in the Philippines is considerably underutilized as already noted, and the experience of a relatively lower maintenance cost for portland-cement concrete pavements.

A more effective implementation of government policy seems practical, if a quick analytical method for the quantitative evaluation of alternative pavement designs were to become available. Such a road-pavement evaluation method could be useful to increase the likelihood that the most appropriate pavement design is selected. For example, the following procedure could become practical:

- compile a table of data comparing alternative pavement designs in terms of quantitative criteria such as total initial cost, global cost over the life of the road, and foreign exchange and local labor components of such costs. Global costs may be defined as a summation of the initial cost to construct and the periodic future costs to restore the facility to initial condition. The method of reducing the future costs to their values at the time of initial construction (i.e., the discounting procedure) is based on criteria that vary with the local economic situation and with subjective factors.

- given such a comparison and a conclusion regarding the selection of pavement type, explore the sensitivity of the result to variations in factors such as the discount rate, or the cost of a specific material.

- apply the result either to recheck the selection already made for a pavement type for roads designed but not yet under construction, or to new road projects not yet designed.

A pavement evaluator capable of performing such a function speedily should take the form of a program suited to one of the computers available to the BPH.

1. The Original Plan

The original plan was based on forecasting maintenance costs using mathematical techniques described in literature, which forecast quantitatively road deterioration in terms of traffic, its distribution, and the time elapsed since the initial construction of the pavement. The techniques also allow for local variations of weather conditions. Then, maintenance policies can be established based on repairing the structure of the road and the road surface when safe vehicle speeds must be reduced to a level lower than that desired.

Such a technique has been suggested in the work of the IBRD* in 1970, which later (in August 1972) was expanded by the Department of Civil Engineering of the Massachusetts Institute of Technology for the U.S. Department of Transportation. In this work mathematical relationships were specifically identified and employed which relate the maximum safe speed of a vehicle to the roughness of the road, and which forecast the roughness that will be generated in a new road surface, or in a maintained surface, by a given traffic flow.

The relationship of road deterioration with traffic and the distribution of the traffic used in the IBRD work is developed in the literature, namely

> Highway Research Board, "The AASHO Road Test", Special Report 61E, Publication No. 954, Washington, D.C., National Research Council, 1962.

The relationship of the maximum vehicle-speed with road roughness used in the IBRD work is developed in the literature, namely

> Bunce, J. A. and Tresidder, J. O., "The Characteristics of Rural Roads in Jamaica as They Affect Traffic Speeds and Vehicle Operating Cost", The Institute of Civil Engineers, London, 1967.

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* International Bank for Reconstruction and Development, Economics Department Working Paper No. 96, Highway Design Phase I - The Model. January 1971, prepared by CLM Systems, Inc. of Cambridge, Massachusetts.

The PTAP understands that additional data with respect to these relationships are currently being collected by the IBRD through their sponsorship of data-collection projects in Africa.

A preliminary inspection of the mathematical relationships cited indicates that they are empirically derived, and that data reflecting Philippine conditions would be required in order to adjust the constants involved in the equations. But on detailed study, the PTAP determined that specific Philippine data were not available, and more importantly, it is questionable as to whether the equations have the proper functional forms in terms of accounting for the important parameters.

Therefore, the PTAP concluded that for the present the model for the pavement evaluator should be based on current BPH maintenance practices rather than on any attempt at the present time to forecast what these practices should be in terms of the service conditions to which a road is subjected.

2. Present Status of the Pavement Evaluator

Accordingly, a computer pavement evaluator program was developed, which compares the costs associated with alternative pavements and the base courses using current BPH maintenance policy. Present construction cost and future maintenance and resurfacing costs (discounted to present values) and the foreign exchange and local labor components of these costs are all compared. The operational details of the pavement-evaluator program are described in Appendix I.

With respect to the original construction of each alternative pavement type under consideration, data are supplied to the program regarding the thickness, width, density, and cost per ton of material in place (exclusive of overhead and profit) for each pavement course and base course. The subbase construction is presumed to be the same regardless of the choice of pavement type, and hence this construction item is not included. Similarly, data are supplied for the width, intensity of application (kg/sq. m), and cost per sq. m. in place, for each coating.

With respect to the future maintenance, the basic cost per km., the appropriate adjustment factors for width, and for pavement type and traffic count, are supplied to conform with current BPH policy (which follows the terms

of the Presidential Decree No. 17). When resurfacing is intended, the period between resurfacing operations is specified as an input data item. The appropriate resurfacing course data and coating data are supplied in the same manner as described above for the original construction. All costs are further broken down into foreign exchange component and local labor component based on predetermined percentages.

The program reads the above data for the pavement in question from a series of punched cards, and then prints a summary of what it has read. The program then calculates the direct costs associated with the original construction of the pavement including the base course and the breakdown of such costs into foreign exchange and local labor components. As noted above, the assumption is made that the sub-base construction does not appreciably affect the pavement choice, and is therefore not included in the analysis.

Next, the maintenance cost and the resurfacing cost (if any) in future years are calculated, together with their breakdown into foreign exchange and local labor content. Costs in future years are discounted back to their values at year zero (year of original construction). To the original cost of construction is added the discounted maintenance and/or reconstruction cost for the pavement from year to year to obtain the accumulation of the global cost for the pavement for each year up to the end of the life, i.e., year 20. The program produces a series of tables for various annual discount rates. Each table presents the total present cost of constructing, maintaining, and resurfacing one kilometer length of road for the particular discount rate considered.

For the purpose of making a sample run of the pavement-evaluator program, a road project of current interest to the BPH was selected. This is the Cotabato-Digos road in Mindanao, which has been the subject of study by firm of SAUTI in 1970. The data are therefore somewhat aged, but in the view of the PTAP are still acceptable for the purpose. The print-out of the input data for the asphalt-concrete pavement in this example is shown in Figure 6a. A corresponding input printout for the cement-concrete pavement is shown in Figure 6b. The output data printout for the asphalt concrete pavement is shown in Figures 7a through 7f for a discount rate range of 6% to 16%. Correspondingly, the output data printout for the cement-concrete pavement in the same discount rate range is shown in Figures 8a through 8f.

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
ASPHALT CEMENT CASE

SUMMARY OF INPUT DATA

COURSES	THICKNESS	WIDTH	T/CU M	PESOS/T	PCT FOREIGN	PCT LCL LBR
WEARING	0.030	6.70	2.40	43.27	50.0	25.0
BINDER	0.040	6.70	2.35	33.95	50.0	25.0
BASE	0.160	7.10	2.30	33.81	50.0	25.0
RE-SRFC	0.025	6.70	2.40	43.27	50.0	25.0

COATINGS	WIDTH	KG/SQ M	PESOS/SQ M	PCT FOREIGN	PCT LCL LBR
SRFC TRT	6.70	2.9	1.08	50.0	25.0
TACK	6.70	0.4	0.29	50.0	25.0
PRIME	6.70	1.2	0.52	50.0	25.0
RE-SRFC	6.70	2.9	1.08	50.0	25.0
RE-TACK	6.70	0.4	0.29	50.0	25.0

ANNUAL MAINTENANCE COST FACTORS
BASIC MAINT COST = 4500. PESOS/KM
FACTOR FOR WIDTH = 1.00
FACTOR FOR ADT AND PAVEMENT = 1.40
PCT FOREIGN COMPONENT = 40.0
PCT LOCAL LABOR COMPONENT = 26.0
RESURFACING PERIOD = 8.0 YEARS

FIGURE 6 a

INPUT DATA PRINTOUT

ASPHALT-CONCRETE PAVEMENT EXAMPLE

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
CEMENT CONCRETE CASE

SUMMARY OF INPUT DATA

COURSES	THICKNESS	WIDTH	T/CU M	PESOS/T	PCT FOREIGN	PCT LCL LBR
CONCRETE	0.200	6.70	2.44	34.11	50.0	25.0
BASE	0.140	7.10	2.30	34.00	50.0	25.0

COATINGS	WIDTH	KG/SQ M	PESOS/SQ M	PCT FOREIGN	PCT LCL LBR
PRIME	6.70	1.2	0.52	50.0	25.0

ANNUAL MAINTENANCE COST FACTORS
BASIC MAINT COST = 4500. PESOS/KM
FACTOR FOR WIDTH = 1.00
FACTOR FOR ADT AND PAVEMENT = 0.90
PCT FOREIGN COMPONENT = 40.0
PCT LOCAL LABOR COMPONENT = 26.0
NO RESURFACING

FIGURE 6 b

INPUT DATA PRINTOUT

CEMENT-CONCRETE PAVEMENT EXAMPLE

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
ASPHALT CEMENT CASE

OUTPUT TABLE 1

RESULTS FOR DISCOUNT RATE OF 6.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	143256.	143256.	143256.	71628.	71628.	71628.	35814.	35814.	35814.
1	6300.	5943.	149200.	2520.	2377.	74005.	1638.	1545.	37359.
2	6300.	5607.	154807.	2520.	2243.	76248.	1638.	1458.	38817.
3	6300.	5290.	160096.	2520.	2116.	78364.	1638.	1375.	40193.
4	6300.	4990.	165087.	2520.	1996.	80360.	1638.	1297.	41490.
5	6300.	4708.	169794.	2520.	1883.	82243.	1638.	1224.	42714.
6	6300.	4441.	174235.	2520.	1777.	84020.	1638.	1155.	43869.
7	6300.	4190.	178425.	2520.	1676.	85696.	1638.	1089.	44958.
8	32874.	20625.	199051.	15807.	9917.	95613.	8281.	5196.	50154.
9	6300.	3729.	202780.	2520.	1492.	97105.	1638.	970.	51123.
10	6300.	3518.	206297.	2520.	1407.	98512.	1638.	915.	52038.
11	6300.	3319.	209616.	2520.	1328.	99839.	1638.	863.	52901.
12	6300.	3131.	212747.	2520.	1252.	101091.	1638.	814.	53715.
13	6300.	2954.	215701.	2520.	1181.	102273.	1638.	768.	54483.
14	6300.	2787.	218487.	2520.	1115.	103387.	1638.	724.	55207.
15	6300.	2629.	221116.	2520.	1052.	104439.	1638.	683.	55891.
16	32874.	12941.	234057.	15807.	6222.	110661.	8281.	3260.	59151.
17	6300.	2340.	236396.	2520.	936.	111597.	1638.	608.	59759.
18	6300.	2207.	238603.	2520.	883.	112480.	1638.	574.	60333.
19	6300.	2082.	240685.	2520.	833.	113313.	1638.	541.	60874.
20	6300.	1964.	242650.	2520.	786.	114098.	1638.	511.	61385.

FIGURE 7 a

OUTPUT DATA PRINTOUT

ASPHALT-CONCRETE EXAMPLE

DISCOUNT RATE 6%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
ASPHALT CEMENT CASE

OUTPUT TABLE 2

RESULTS FOR DISCOUNT RATE OF 8.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	143256.	143256.	143256.	71628.	71628.	71628.	35814.	35814.	35814.
1	6300.	5833.	149090.	2520.	2333.	73961.	1638.	1517.	37331.
2	6300.	5401.	154491.	2520.	2160.	76122.	1638.	1404.	38735.
3	6300.	5001.	159492.	2520.	2000.	78122.	1638.	1300.	40035.
4	6300.	4631.	164123.	2520.	1852.	79975.	1638.	1204.	41239.
5	6300.	4288.	168410.	2520.	1715.	81690.	1638.	1115.	42354.
6	6300.	3970.	172380.	2520.	1588.	83278.	1638.	1032.	43386.
7	6300.	3676.	176056.	2520.	1470.	84748.	1638.	956.	44342.
8	32874.	17761.	193817.	15807.	9540.	93288.	8281.	4474.	48816.
9	6300.	3152.	196968.	2520.	1261.	94549.	1638.	819.	49636.
10	6300.	2918.	199886.	2520.	1167.	95716.	1638.	759.	50394.
11	6300.	2702.	202588.	2520.	1081.	96796.	1638.	703.	51097.
12	6300.	2502.	205090.	2520.	1001.	97797.	1638.	650.	51747.
13	6300.	2316.	207407.	2520.	927.	98724.	1638.	602.	52350.
14	6300.	2145.	209552.	2520.	858.	99582.	1638.	558.	52907.
15	6300.	1986.	211538.	2520.	794.	100376.	1638.	516.	53424.
16	32874.	9595.	221133.	15807.	4614.	104990.	8281.	2417.	55841.
17	6300.	1703.	222836.	2520.	681.	105671.	1638.	443.	56284.
18	6300.	1577.	224412.	2520.	631.	106302.	1638.	410.	56694.
19	6300.	1460.	225872.	2520.	584.	106885.	1638.	380.	57073.
20	6300.	1352.	227224.	2520.	541.	107426.	1638.	351.	57425.

FIGURE 7 b

OUTPUT DATA PRINTOUT

ASPHALT-CONCRETE EXAMPLE

DISCOUNT RATE 8%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
ASPHALT CEMENT CASE

OUTPUT TABLE 3

RESULTS FOR DISCOUNT RATE OF 10.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	143256.	143256.	143256.	71628.	71628.	71628.	35814.	35814.	35814.
1	6300.	5727.	148984.	2520.	2291.	73919.	1638.	1489.	37303.
2	6300.	5207.	154190.	2520.	2083.	76002.	1638.	1354.	38657.
3	6300.	4733.	158924.	2520.	1893.	77895.	1638.	1231.	39888.
4	6300.	4303.	163226.	2520.	1721.	79616.	1638.	1119.	41006.
5	6300.	3912.	167138.	2520.	1565.	81181.	1638.	1017.	42023.
6	6300.	3556.	170694.	2520.	1422.	82603.	1638.	925.	42948.
7	6300.	3233.	173927.	2520.	1293.	83896.	1638.	841.	43789.
8	32874.	15336.	189263.	15807.	7374.	91270.	8281.	3863.	47652.
9	6300.	2672.	191935.	2520.	1069.	92339.	1638.	695.	48347.
10	6300.	2429.	194364.	2520.	972.	93311.	1638.	632.	48978.
11	6300.	2208.	196572.	2520.	883.	94194.	1638.	574.	49552.
12	6300.	2007.	198579.	2520.	803.	94997.	1638.	522.	50074.
13	6300.	1825.	200404.	2520.	730.	95727.	1638.	474.	50549.
14	6300.	1659.	202063.	2520.	664.	96390.	1638.	431.	50980.
15	6300.	1508.	203571.	2520.	603.	96993.	1638.	392.	51372.
16	32874.	7154.	210725.	15807.	3440.	100433.	8281.	1802.	53174.
17	6300.	1246.	211972.	2520.	499.	100932.	1638.	324.	53498.
18	6300.	1133.	213105.	2520.	453.	101385.	1638.	295.	53793.
19	6300.	1030.	214135.	2520.	412.	101797.	1638.	268.	54061.
20	6300.	936.	215071.	2520.	375.	102172.	1638.	243.	54304.

FIGURE 7 e

OUTPUT DATA PRINTOUT

ASPHALT-CONCRETE EXAMPLE

DISCOUNT RATE 10%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
ASPHALT CEMENT CASE

OUTPUT TABLE 4

RESULTS FOR DISCOUNT RATE OF 12.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	143256.	143256.	143256.	71628.	71628.	71628.	35814.	35814.	35814.
1	6300.	5625.	148881.	2520.	2250.	73878.	1638.	1462.	37277.
2	6300.	5022.	153904.	2520.	2009.	75887.	1638.	1306.	38582.
3	6300.	4484.	158388.	2520.	1794.	77681.	1638.	1166.	39748.
4	6300.	4004.	162392.	2520.	1602.	79282.	1638.	1041.	40789.
5	6300.	3575.	165966.	2520.	1430.	80712.	1638.	929.	41719.
6	6300.	3192.	169158.	2520.	1277.	81989.	1638.	830.	42549.
7	6300.	2850.	172008.	2520.	1140.	83129.	1638.	741.	43290.
8	32874.	13277.	185285.	15807.	6384.	89513.	8281.	3345.	46634.
9	6300.	2272.	187557.	2520.	909.	90421.	1638.	591.	47225.
10	6300.	2028.	189585.	2520.	811.	91233.	1638.	527.	47752.
11	6300.	1811.	191396.	2520.	724.	91957.	1638.	471.	48223.
12	6300.	1617.	193013.	2520.	647.	92604.	1638.	420.	48644.
13	6300.	1444.	194457.	2520.	578.	93181.	1638.	375.	49019.
14	6300.	1289.	195746.	2520.	516.	93697.	1638.	335.	49354.
15	6300.	1151.	196897.	2520.	460.	94157.	1638.	299.	49653.
16	32874.	5362.	202259.	15807.	2578.	96736.	8281.	1351.	51004.
17	6300.	918.	203177.	2520.	367.	97103.	1638.	239.	51243.
18	6300.	819.	203996.	2520.	328.	97430.	1638.	213.	51456.
19	6300.	731.	204727.	2520.	293.	97723.	1638.	190.	51646.
20	6300.	653.	205380.	2520.	261.	97984.	1638.	170.	51816.

FIGURE 7 d

OUTPUT DATA PRINTOUT

ASPHALT-CONCRETE EXAMPLE

DISCOUNT RATE 12%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
ASPHALT CEMENT CASE

OUTPUT TABLE 5

RESULTS FOR DISCOUNT RATE OF 14.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	143256.	143256.	143256.	71628.	71628.	71628.	35814.	35814.	35814.
1	6300.	5526.	148783.	2520.	2211.	73839.	1638.	1437.	37251.
2	6300.	4848.	153630.	2520.	1939.	75778.	1638.	1260.	38511.
3	6300.	4252.	157883.	2520.	1701.	77479.	1638.	1106.	39617.
4	6300.	3730.	161613.	2520.	1492.	78971.	1638.	970.	40587.
5	6300.	3272.	164885.	2520.	1309.	80279.	1638.	851.	41438.
6	6300.	2870.	167755.	2520.	1148.	81427.	1638.	746.	42184.
7	6300.	2518.	170273.	2520.	1007.	82434.	1638.	655.	42838.
8	32874.	11524.	181797.	15807.	5541.	87976.	8281.	2903.	45741.
9	6300.	1937.	183734.	2520.	775.	88750.	1638.	504.	46245.
10	6300.	1699.	185433.	2520.	680.	89430.	1638.	442.	46687.
11	6300.	1491.	186924.	2520.	596.	90026.	1638.	388.	47075.
12	6300.	1308.	188232.	2520.	523.	90549.	1638.	340.	47415.
13	6300.	1147.	189379.	2520.	459.	91008.	1638.	298.	47713.
14	6300.	1006.	190385.	2520.	402.	91411.	1638.	262.	47974.
15	6300.	883.	191267.	2520.	353.	91764.	1638.	229.	48204.
16	32874.	4040.	195307.	15807.	1943.	93706.	8281.	1018.	49222.
17	6300.	679.	195986.	2520.	272.	93978.	1638.	177.	49398.
18	6300.	596.	196582.	2520.	238.	94216.	1638.	155.	49553.
19	6300.	523.	197105.	2520.	209.	94425.	1638.	136.	49689.
20	6300.	458.	197563.	2520.	183.	94608.	1638.	119.	49808.

FIGURE 7 •

OUTPUT DATA PRINTOUT

ASPHALT-CONCRETE EXAMPLE

DISCOUNT RATE 14%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
ASPHALT CEMENT CASE

OUTPUT TABLE 6

RESULTS FOR DISCOUNT RATE OF 16.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	143256.	143256.	143256.	71628.	71628.	71628.	35814.	35814.	35814.
1	6300.	5431.	148687.	2520.	2172.	73801.	1638.	1412.	37226.
2	6300.	4682.	153369.	2520.	1873.	75673.	1638.	1217.	38444.
3	6300.	4036.	157405.	2520.	1614.	77288.	1638.	1049.	39493.
4	6300.	3479.	160885.	2520.	1392.	78679.	1638.	905.	40398.
5	6300.	3000.	163884.	2520.	1200.	79879.	1638.	780.	41177.
6	6300.	2586.	166470.	2520.	1034.	80914.	1638.	672.	41850.
7	6300.	2229.	168699.	2520.	892.	81805.	1638.	580.	42429.
8	32874.	10027.	178726.	15807.	4821.	86627.	8281.	2526.	44955.
9	6300.	1657.	180383.	2520.	663.	87289.	1638.	431.	45386.
10	6300.	1428.	181811.	2520.	571.	87860.	1638.	371.	45757.
11	6300.	1231.	183042.	2520.	492.	88353.	1638.	320.	46077.
12	6300.	1061.	184104.	2520.	425.	88777.	1638.	276.	46353.
13	6300.	915.	185018.	2520.	366.	89143.	1638.	238.	46591.
14	6300.	789.	185807.	2520.	315.	89459.	1638.	205.	46796.
15	6300.	680.	186487.	2520.	272.	89731.	1638.	177.	46973.
16	32874.	3059.	189546.	15807.	1471.	91201.	8281.	771.	47744.
17	6300.	505.	190051.	2520.	202.	91403.	1638.	131.	47875.
18	6300.	436.	190486.	2520.	174.	91578.	1638.	113.	47988.
19	6300.	376.	190862.	2520.	150.	91728.	1638.	98.	48086.
20	6300.	324.	191186.	2520.	129.	91857.	1638.	84.	48170.

FIGURE 7 f

OUTPUT DATA PRINTOUT

ASPHALT-CONCRETE EXAMPLE

DISCOUNT RATE 16%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
CEMENT CONCRETE CASE

OUTPUT TABLE 1

RESULTS FOR DISCOUNT RATE OF 6.0 PERCENT PER YEAR

YEARS OF USE	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	192741.	192741.	192741.	96370.	96370.	96370.	48185.	48185.	48185.
1	4050.	3821.	196561.	1620.	1528.	97898.	1053.	993.	49179.
2	4050.	3604.	200166.	1620.	1442.	99340.	1053.	937.	50116.
3	4050.	3400.	203566.	1620.	1360.	100700.	1053.	884.	51000.
4	4050.	3208.	206774.	1620.	1283.	101983.	1053.	834.	51834.
5	4050.	3026.	209800.	1620.	1211.	103194.	1053.	787.	52621.
6	4050.	2855.	212656.	1620.	1142.	104336.	1053.	742.	53363.
7	4050.	2693.	215349.	1620.	1077.	105413.	1053.	700.	54063.
8	4050.	2541.	217890.	1620.	1016.	106430.	1053.	661.	54724.
9	4050.	2397.	220287.	1620.	959.	107389.	1053.	623.	55347.
10	4050.	2262.	222549.	1620.	905.	108293.	1053.	588.	55935.
11	4050.	2134.	224682.	1620.	853.	109147.	1053.	555.	56490.
12	4050.	2013.	226695.	1620.	805.	109952.	1053.	523.	57013.
13	4050.	1899.	228594.	1620.	760.	110711.	1053.	494.	57507.
14	4050.	1791.	230385.	1620.	717.	111428.	1053.	466.	57973.
15	4050.	1690.	232075.	1620.	676.	112104.	1053.	439.	58412.
16	4050.	1594.	233669.	1620.	638.	112741.	1053.	415.	58827.
17	4050.	1504.	235173.	1620.	602.	113343.	1053.	391.	59218.
18	4050.	1419.	236592.	1620.	568.	113910.	1053.	369.	59587.
19	4050.	1339.	237930.	1620.	535.	114446.	1053.	348.	59935.
20	4050.	1263.	239193.	1620.	505.	114951.	1053.	328.	60263.

FIGURE 8 a

OUTPUT DATA PRINTOUT

CEMENT-CONCRETE PAVEMENT EXAMPLE

DISCOUNT RATE 6%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
CEMENT CONCRETE CASE

OUTPUT TABLE 2

RESULTS FOR DISCOUNT RATE OF 8.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	192741.	192741.	192741.	96370.	96370.	96370.	48185.	48185.	48185.
1	4050.	3750.	196490.	1620.	1500.	97870.	1053.	975.	49160.
2	4050.	3472.	199963.	1620.	1389.	99259.	1053.	903.	50063.
3	4050.	3215.	203178.	1620.	1286.	100545.	1053.	836.	50899.
4	4050.	2977.	206154.	1620.	1191.	101736.	1053.	774.	51673.
5	4050.	2756.	208911.	1620.	1103.	102838.	1053.	717.	52389.
6	4050.	2552.	211463.	1620.	1021.	103859.	1053.	664.	53053.
7	4050.	2363.	213826.	1620.	945.	104804.	1053.	614.	53667.
8	4050.	2188.	216014.	1620.	875.	105679.	1053.	569.	54236.
9	4050.	2026.	218040.	1620.	810.	106490.	1053.	527.	54763.
10	4050.	1876.	219916.	1620.	750.	107240.	1053.	488.	55251.
11	4050.	1737.	221653.	1620.	695.	107935.	1053.	452.	55702.
12	4050.	1608.	223261.	1620.	643.	108578.	1053.	418.	56121.
13	4050.	1489.	224750.	1620.	596.	109174.	1053.	387.	56508.
14	4050.	1379.	226129.	1620.	552.	109725.	1053.	359.	56866.
15	4050.	1277.	227406.	1620.	511.	110236.	1053.	332.	57198.
16	4050.	1182.	228588.	1620.	473.	110709.	1053.	307.	57506.
17	4050.	1095.	229682.	1620.	438.	111147.	1053.	285.	57790.
18	4050.	1014.	230696.	1620.	405.	111552.	1053.	264.	58054.
19	4050.	938.	231634.	1620.	375.	111927.	1053.	244.	58298.
20	4050.	869.	232503.	1620.	348.	112275.	1053.	226.	58524.

FIGURE 8 b

OUTPUT DATA PRINTOUT

CEMENT-CONCRETE PAVEMENT EXAMPLE

DISCOUNT RATE 8%

4

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
CEMENT CONCRETE CASE

OUTPUT TABLE 3

RESULTS FOR DISCOUNT RATE OF 10.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	192741.	192741.	192741.	96370.	96370.	96370.	48185.	48185.	48185.
1	4050.	3682.	196422.	1620.	1473.	97843.	1053.	957.	49142.
2	4050.	3347.	199769.	1620.	1339.	99182.	1053.	870.	50013.
3	4050.	3043.	202812.	1620.	1217.	100399.	1053.	791.	50804.
4	4050.	2766.	205578.	1620.	1106.	101505.	1053.	719.	51523.
5	4050.	2515.	208093.	1620.	1006.	102511.	1053.	654.	52177.
6	4050.	2286.	210379.	1620.	914.	103426.	1053.	594.	52771.
7	4050.	2078.	212457.	1620.	831.	104257.	1053.	540.	53312.
8	4050.	1889.	214347.	1620.	756.	105013.	1053.	491.	53803.
9	4050.	1718.	216064.	1620.	687.	105700.	1053.	447.	54249.
10	4050.	1561.	217626.	1620.	625.	106324.	1053.	406.	54655.
11	4050.	1420.	219045.	1620.	568.	106892.	1053.	369.	55024.
12	4050.	1290.	220336.	1620.	516.	107408.	1053.	336.	55360.
13	4050.	1173.	221509.	1620.	469.	107877.	1053.	305.	55665.
14	4050.	1066.	222575.	1620.	427.	108304.	1053.	277.	55942.
15	4050.	970.	223545.	1620.	388.	108692.	1053.	252.	56194.
16	4050.	881.	224426.	1620.	353.	109044.	1053.	229.	56423.
17	4050.	801.	225227.	1620.	321.	109365.	1053.	208.	56632.
18	4050.	728.	225956.	1620.	291.	109655.	1053.	189.	56821.
19	4050.	662.	226618.	1620.	265.	109921.	1053.	172.	56993.
20	4050.	602.	227220.	1620.	241.	110162.	1053.	157.	57150.

FIGURE 8 c

OUTPUT DATA PRINTOUT

CEMENT-CONCRETE PAVEMENT EXAMPLE

DISCOUNT RATE 10%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
CEMENT CONCRETE CASE

OUTPUT TABLE 4

RESULTS FOR DISCOUNT RATE OF 12.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	192741.	192741.	192741.	96370.	96370.	96370.	48185.	48185.	48185.
1	4050.	3616.	196357.	1620.	1446.	97817.	1053.	940.	49125.
2	4050.	3229.	199585.	1620.	1291.	99108.	1053.	839.	49965.
3	4050.	2883.	202468.	1620.	1153.	100261.	1053.	750.	50714.
4	4050.	2574.	205042.	1620.	1030.	101291.	1053.	669.	51383.
5	4050.	2298.	207340.	1620.	919.	102210.	1053.	597.	51981.
6	4050.	2052.	209392.	1620.	821.	103030.	1053.	533.	52514.
7	4050.	1832.	211224.	1620.	733.	103763.	1053.	476.	52991.
8	4050.	1636.	212859.	1620.	654.	104417.	1053.	425.	53416.
9	4050.	1460.	214320.	1620.	584.	105002.	1053.	380.	53796.
10	4050.	1304.	215624.	1620.	522.	105523.	1053.	339.	54135.
11	4050.	1164.	216788.	1620.	466.	105989.	1053.	303.	54437.
12	4050.	1040.	217827.	1620.	416.	106405.	1053.	270.	54708.
13	4050.	928.	218756.	1620.	371.	106776.	1053.	241.	54949.
14	4050.	829.	219584.	1620.	331.	107107.	1053.	215.	55165.
15	4050.	740.	220324.	1620.	296.	107403.	1053.	192.	55357.
16	4050.	661.	220985.	1620.	264.	107668.	1053.	172.	55529.
17	4050.	590.	221575.	1620.	236.	107903.	1053.	153.	55682.
18	4050.	527.	222101.	1620.	211.	108114.	1053.	137.	55819.
19	4050.	470.	222571.	1620.	188.	108302.	1053.	122.	55941.
20	4050.	420.	222991.	1620.	168.	108470.	1053.	109.	56050.

FIGURE 8 d

OUTPUT DATA PRINTOUT

CEMENT-CONCRETE PAVEMENT EXAMPLE

DISCOUNT RATE 12%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
CEMENT CONCRETE CASE

OUTPUT TABLE 5

RESULTS FOR DISCOUNT RATE OF 14.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	192741.	192741.	192741.	96370.	96370.	96370.	48185.	48185.	48185.
1	4050.	3553.	196293.	1620.	1421.	97791.	1053.	924.	49109.
2	4050.	3116.	199409.	1620.	1247.	99038.	1053.	810.	49919.
3	4050.	2734.	202143.	1620.	1093.	100131.	1053.	711.	50630.
4	4050.	2398.	204541.	1620.	959.	101090.	1053.	623.	51253.
5	4050.	2103.	206644.	1620.	841.	101932.	1053.	547.	51800.
6	4050.	1845.	208490.	1620.	738.	102670.	1053.	480.	52280.
7	4050.	1619.	210108.	1620.	647.	103317.	1053.	421.	52701.
8	4050.	1420.	211528.	1620.	568.	103885.	1053.	369.	53070.
9	4050.	1245.	212773.	1620.	498.	104383.	1053.	324.	53394.
10	4050.	1092.	213866.	1620.	437.	104820.	1053.	284.	53678.
11	4050.	958.	214824.	1620.	383.	105203.	1053.	249.	53927.
12	4050.	841.	215664.	1620.	336.	105539.	1053.	219.	54145.
13	4050.	737.	216402.	1620.	295.	105834.	1053.	192.	54337.
14	4050.	647.	217049.	1620.	259.	106093.	1053.	168.	54505.
15	4050.	567.	217616.	1620.	227.	106320.	1053.	148.	54653.
16	4050.	498.	218114.	1620.	199.	106519.	1053.	129.	54782.
17	4050.	437.	218550.	1620.	175.	106694.	1053.	114.	54896.
18	4050.	383.	218933.	1620.	153.	106847.	1053.	100.	54995.
19	4050.	336.	219269.	1620.	134.	106981.	1053.	87.	55083.
20	4050.	295.	219564.	1620.	118.	107099.	1053.	77.	55159.

FIGURE 8 e

OUTPUT DATA PRINTOUT

CEMENT-CONCRETE PAVEMENT EXAMPLE

DISCOUNT RATE 14%

PAVEMENT EVALUATOR PROGRAM
COTABATO-DIGOS ROAD -- RUN OF MARCH 20, 1973, FOR DEMONSTRATION PURPOSES
CEMENT CONCRETE CASE

OUTPUT TABLE 6

RESULTS FOR DISCOUNT RATE OF 16.0 PERCENT PER YEAR

	DIRECT PAVEMENT-AND-BASE COSTS, P/KM			FOREIGN COMPONENT, P/KM			LOCAL LABOR COMPONENT, P/KM		
YEARS OF USE	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT	ANNUAL	ANNUAL, DISCOUNTED TO PRESENT	CUM COSTS, DISCOUNTED TO PRESENT
0	192741.	192741.	192741.	96370.	96370.	96370.	48185.	48185.	48185.
1	4050.	3491.	196232.	1620.	1397.	97767.	1053.	908.	49093.
2	4050.	3010.	199242.	1620.	1204.	98971.	1053.	783.	49875.
3	4050.	2595.	201836.	1620.	1038.	100008.	1053.	675.	50550.
4	4050.	2237.	204073.	1620.	895.	100903.	1053.	582.	51132.
5	4050.	1928.	206001.	1620.	771.	101674.	1053.	501.	51633.
6	4050.	1662.	207664.	1620.	665.	102339.	1053.	432.	52065.
7	4050.	1433.	209097.	1620.	573.	102912.	1053.	373.	52438.
8	4050.	1235.	210332.	1620.	494.	103406.	1053.	321.	52759.
9	4050.	1065.	211397.	1620.	426.	103832.	1053.	277.	53036.
10	4050.	918.	212315.	1620.	367.	104200.	1053.	239.	53274.
11	4050.	791.	213106.	1620.	317.	104516.	1053.	206.	53480.
12	4050.	682.	213789.	1620.	273.	104789.	1053.	177.	53658.
13	4050.	588.	214377.	1620.	235.	105024.	1053.	153.	53811.
14	4050.	507.	214884.	1620.	203.	105227.	1053.	132.	53942.
15	4050.	437.	215321.	1620.	175.	105402.	1053.	114.	54056.
16	4050.	377.	215698.	1620.	151.	105553.	1053.	98.	54154.
17	4050.	325.	216022.	1620.	130.	105682.	1053.	84.	54238.
18	4050.	280.	216302.	1620.	112.	105794.	1053.	73.	54311.
19	4050.	241.	216544.	1620.	97.	105891.	1053.	63.	54374.
20	4050.	208.	216752.	1620.	83.	105974.	1053.	54.	54428.

FIGURE 8 1

OUTPUT DATA PRINTOUT

CEMENT-CONCRETE PAVEMENT EXAMPLE

DISCOUNT RATE 16%

A comparison of the results shows that only at the lowest discount rate considered (6%) does the lower future maintenance cost associated with the cement concrete pavement bring the global cost for this type of pavement into the same order of magnitude as that for the asphalt-cement pavement. But this finding is only hypothetical in view of the discussion which follows.

The maintenance practices, on which the example was based, are not at all realistic for use as a basis for evaluating pavement performance and costs under actual service conditions. As already discussed, the program should attempt to calculate the change in performance of a road pavement as actual wear occurs due to traffic and weather, as is done, for example, in the Massachusetts Institute of Technology highway cost model, noted above. Also as discussed above, data required for this purpose are not presently available in the BPH, and the application of such complex relationships is not yet justified.

Moreover, the breakdown of costs to show their foreign-exchange and local-labor components have been rather arbitrarily adapted. Reliable cost analyses in these respects are needed.

Therefore, the current status of the pavement-evaluator program is that one should not yet draw from its use conclusions regarding the total global costs of alternative pavements. Rather, as time goes on, the program should be further developed by compiling the data especially with respect to realistic maintenance needs rather than from arbitrary maintenance practices, and then introducing changes into the program in order to accommodate such data.

C. OTHER POTENTIAL PROGRAMS

One reason for developing and testing the pavement-evaluator computer program was to determine what obstacles exist that may hinder the Bureau's increased usage of computers in technical/economic calculations. The PTAP found that, although the Bureau's IBM 1440 (8K) computer is not able to handle Fortran programs at this time, there are other machines in the area available for rental on an hourly basis (IBM/Makati's IBM 360 and BUTEL IBM 1130 -- the latter on weekends only), and capable of handling Fortran. Indeed, at least one BPH employee is already doing just this, using the

BUTEL computer on weekends with Fortran programs.

The PTAP made its demonstration run at IBM/Makati. A lack of available machines, then is not the factor limiting the Bureau's expansion of computer usage.

Moreover, the personnel of the Bureau's Electronic Data-Processing Section on their own suggestion, and with the cooperation of the PTAP, have been able to rewrite the Fortran program (Appendix I, Figures 1-1a through 1-1d) using the IOCS language, and to run it successfully on the Bureau's IBM 1440. Although the printout of the program in IOCS runs 19 pages as compared with 4 pages in Fortran, the machine time during the run was only about 5 minutes. This experience serves to illustrate the potential in the Bureau personnel and equipment for undertaking a greater utilization of the computer methods in the Bureau's operations.

Two potential additional applications will arise as soon as the actions are taken with respect to the results of the PTAP work in the labor-intensive construction of roads and highways and in the prolonging of the service life of heavy construction equipment. Both sets of results involve in their implementation a continuous and immediate need for high-speed data processing and repetitive calculations. The labor-intensive topic involves the processing of extraordinary numbers of data sets (possibly 10,000 sets for the Capas-Botolan pilot project alone). The equipment service-life topic involves the keeping of continuous records for each equipment unit in the BPH inventory (currently about 850 bulldozers and 3,500 dump trucks) and the performing rapid calculations of the periodic maintenance and operating costs of each unit. It is not practical to undertake these tasks with manual methods, if effective implementation of the results of the PTAP work is to be achieved.

Table 20 presents a list of the reports periodically issued by the Electronic Data-Processing Section of the BPH. The tasks they undertake currently are largely of an accounting nature. The translation of the Pavement-Evaluator Program from Fortran to IOCS, and its successful running on the IBM 1440 is probably the first task of a technological nature that the EDP Section has undertaken.

Other areas for computer application in the BPH no doubt exist, each of which, as already noted, could offer an opportunity for the reduction of

TABLE 20

PERIODIC REPORTS PRODUCED BY THE EDP SECTION OF THE BPH

1. "Annual Traffic Accident Report" and the coding of data sheets for the "Origin and Destination Survey."

2. "Equipment Rental Bills," "Monthly Summary of Bills Rendered," "Monthly Report on the Utilization and Earnings of Equipment," "Annual (FY) Equipment Inventory and Statistics," "Quarterly Report on Equipment Location" and "Statement of Accounts of Lessee and Equipment."

3. "Spare Parts Receiving Report," "Spare Parts Catalogs," "Listings of Requisitions for Spare Parts," "Monthly Transaction Report," "Stock Status Report, and Shipping Orders."

4. "General Office Payroll Register," "Monthly Statement of Salary Loan Deductions of Regular Employees," "Monthly Statement of Life and Retirement Premium Deduction of Regular Employees," and "Quarterly Report on the Earnings of Regular Employees."

5. "Quarterly Equipment Report on Operation, Maintenance and Repairs." This is a detailed listing of heavy equipment of the Bureau that are distributed among the highways engineering districts with their respective data on utilization, fuel consumption and repairs.

6. Transcription and processing of employee's personal data for the"Manpower Assessment Survey" sponsored jointly by the Civil Service Commission and the Department of Public Works and Communications.*

* This was a one-time job for the Civil Service Commission.

construction costs by giving the BPH staff the opportunity to explore alternatives. Examples are: CPM/PERT scheduling especially in large-scale labor-intensive projects conducted directly by administration and in preconstruction activities of the Bureau; in iterative calculation encountered in bridge design and earthwork calculation; and in the management and evaluation of traffic studies.

The original basis upon which the BPH installation of the IBM 1440 was justified is the work of the US Bureau of Public Roads in the BPH, reported in 1964*. Eleven suggested technological applications which up to the present have not been adopted, were made on page 10 of the report as follows:

- Gradeline and superelevation computations
- Horizontal Alignment Computations
- Coordinate Adjustment
- Geometric Computations
- Stadia Reductions
- Earthwork Volume Computations
- Computation of Mass Program Ordinates
- Compaction Factor determination
- Computation of Overhaul Quantities
- Contour interpolation
- Solution of Simultaneous Equations

The report (page 11) also mentioned that continuing studies should be made in all fields in the Bureau to find additional applications where advantage can be taken of the abilities of the computer. Opportunities may exist in the field of structural engineering and bridge design. Beam camber, quantities of concrete and steel, and T-beam design computations are examples.

D. APPLICATION TO THE BPH COMPUTER CENTER

The Bureau of Public Highways should seek short-term results by marshalling selected personnel as a task force to provide primarily the capa-

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* Memorandum Report, 16 January 1964, Paul Yeager, U.S. Bureau of Public Roads, Manila - in BPH files.

bility (a) to undertake computer-processing of the data which will arise during the implementation of actions with regard to labor-intensive construction of roads and highways and prolonging the service of heavy equipment; and (b) to identify and develop other applications of computer methods which the task force could identify. The work plan should incorporate the following features:

- list and categorize the major calculation activities within the BPH and identify individuals who have already had, or who might profit from, computer training;
- carefully selecting a few areas in which increased use of computers should be encouraged such as has already been noted above;
- carefully selecting and sending the order of a dozen of its engineering personnel to IBM/Makati's periodic two-week training courses;
- arranging rental contracts with whichever of the externally available computers is cheaper at the time, to allow BPH personnel to run the programs that they may subsequently develop during the course of their work;
- upgrading the Bureau's IBM 1440 only when the external Fortran-run rentals routinely exceed the order of, say, 1,000 pesos per week, or when other data processing loads, such as the accounting work noted in Table 20 on the technical work suggested by Yeager, at the Bureau dictate expansion of the machine to 12K or 16K size; and
- publicizing and coordinating within the BPH, the computer programming capabilities that may already exist, or which subsequently will be develop within the Bureau. Thus, close cooperation between the technical divisions on the one hand and the EDP section on the other should be encouraged to take full advantage of the existing programming capabilities and to develop fully such capabilities.

In addition, the Bureau of Public Highways should organize a road-maintenance cost-data accumulation program, supplementing that which is currently being implemented, that will serve to improve the reliability of the data available for the pavement-evaluator computer program. The work should incorporate the following elements in consecutive steps:

- quantification of the relationships through collection of appropriate data, between BPH actual maintenance experiences (costs) with various payment types, traffic densities, traffic distributions, and weather. Also, the collection of data to enable the allocation of construction and maintenance costs to foreign exchange and local labor components;
- review the sophistication of the present pavement-evaluator program in order to make the changes to take advantage of the potential of the data compilation, for example, to take advantage of the same type of approach as in the literature cited above; and
- continue the two steps outlined above until satisfaction exists that the data base for the pavement-evaluator is sufficiently realistic for the BPH can rely on its results for decision making.

VIII. STEPS TO ACHIEVEMENT

The findings from the work programs for the four topics selected have now been presented and the responsiveness of these findings to national goals can be judged. The significant factor to be reckoned with now becomes the practicality of putting the results into effect within the framework of the organization and practices of the Bureau of Public Highways. As already indicated, the achievement of cost reductions can be more readily assured by the formulation of action plans in which the individual actions are coordinated for implementation in an efficient manner. The aim is to achieve benefits as far as practical in the short term, by avoiding delays where certain related benefits can only be achieved in the long term. The purpose of this Chapter is to organize the findings and conclusions so far reported as a set of action plans responsive to the criteria mentioned above.

It was mentioned in Chapter II, that the PTAP judges the action plans to technically feasible to implement. Three reasons for this judgment exist. They are:

- the details reflect the views of the field personnel of the BPH as these were identified during the field travels of the PTAP;
- the details reflect the views of government and private sector as these were identified during the three day seminar in Quezon City; and
- the BPH is currently undergoing a stage of reorganization of its functions, and this presents a fluid situation for introducing additional change.

A. THE ACTION PLANS

1. The Labor Intensive Construction of Roads and Highways

The objective of the Plan is to assist in the implementation of government policy to promote the large-scale use of labor in the construction of roads and highways throughout the country. The Plan intends to achieve this objective by establishing a master plan to guide the activities of all government agencies concerned with respect to (a) realizing the short-term opportunities to increase labor employment, and (b) realizing the opportunities for the large-scale employment of labor through the adoption as a prototype, the portions of the Marikina-Infanta road

not yet committed for construction. Thus, the Master Plan is to incorporate two sets of activities which are to be accomplished in a parallel manner as follows:

- the first is to be designed to have immediate, or short-term, effects in which labor employment in road construction will have been increased by identifying those areas in the conventional road-construction technology, as presently practiced by the Bureau, where labor can be employed to substitute for machinery at competitive financial cost;
- the second set of activities is to focus, for the model, on the stretches of the Marikina-Infanta road which will pass through publicly-owned lands. The individual activities are to be designed to produce employment opportunities for construction labor as soon as practicable. The design is to take advantage of the results, data, and experiences generated from the first, or short-term, set of activities as these become available.

The elements in the first set of activities are to be aimed at as far as practicable at identifying oppotunities for labor substitution quantitatively, based on:

- a compilation of the experiences from the labor-intensive construction of the six-kilometer stretch of the Capas-Botolan road in a form such that it can have maximum utility for financial-cost and national-economic-cost estimating work;
- an analysis of the work tasks defined (a) in the detailed construction drawings prepared by the Bureau of Public Highways for the stretches of the Marikina-Infanta road that pass through privately-held lands, and (b) from a physical inspection of the rights-of-way of the alignment; and
- the identification of the specific changes to be made to the Bureau of Public Highways contracting procedures, which are necessary in order to remove impediments to realizing those opportunities for using labor more intensively that can be justified because the financial costs are competitive.

As the final action for the first, or short term, set of activities in the Master Plan, the results are to be disseminated throughout the Bureau of Public Highways district, city, and regional offices, with recommendations for their implementation.

The objectives for the second set of activities (i.e., those relevant to the Marikina-Infanta road) to be undertaken in connection with the implementation of the Master Plan have already been listed in Chapter IV.

In the achievement of such objectives, specific efforts are to be undertaken in order to achieve a number of interim objectives. These objectives and an identification of the specific efforts have already been discussed in Chapter IV.

The implementation of the Master Plan, with respect to the satisfactory accomplishment of the two sets of activities discussed above ; be made the responsibility of a Task Force, whose character has already been described in Chapter IV. Likewise, the delegation of authority to the Task force, and its immediate task have already been described in Chapter IV.

2. Prolonging the Service-Life of Heavy Construction Equipment

The PTAP has noted the changes now being implemented in the operations of the Bureau of Public Highways with respect to the management of its inventory of heavy construction equipment, and believes that these changes, particularly the installation of a comprehensive preventive maintenance system (Appendix G) and the maintaining of an adequate inventory of spare parts will have a significant effect in prolonging equipment service-life. Accordingly, the PTAP focussed its attention primarily on identifying opportunities to reduce the costs of the preventive maintenance procedures through increasing their effectiveness, and secondarily on the cost reduction opportunities offered by the longer service lives which should result.

Four separate Action Plans are to be established, each of which can be accomplished without reference to the other, but all of which together should have a pronounced effect on achieving overall the longer service lives. Initially, attention is to continue to focus on the two equipment types so far considered. Each of the four separate action plans is to be geared to a specific objective, as follows:

- the first plan deals with a method for determining the appropriate economic service life of equipment. Involved in the implementation of this plan are the necessary record keeping, the processing of the recorded data, and the decision making process when the time for replacement has come. The accomplishment of this plan is needed in

order to provide a rational framework in which the results of the remaining plans are to operate.

- the second plan is based on the transfer of selected nan-destructive testing technologies to the operations of the regional depots, area shops, and mobile maintenance units. Involved are the identification of appropriate technologies from those already described (Appendix H), the methods of operation and personnel skills required, the justification for installation, and the estimated costs.
- the third plan is based on improving personnel practices which can motivate equipment operators and maintenance mechanics to exercise greater diligence in the care and handling of equipment units. Involved are consideration of pay scales, social benefits, human factors, and training.
- the final plan deals with the local manufacture of spare parts as a means primarily of assuring availability of parts, and of avoiding obsolescence from cessation of foreign manufacture. Involved is cooperation in specific ways with a related interest in local manufacture of the Board of Investments.

As soon as the initial tasks involved in implementing the four action plans are underway, efforts are to be undertaken to:

- bring in other equipment types in the BPH inventory for similar treatment; and
- bring in other equipment-owning agencies of the national or local governments who may be interested in applying the results to their own operations.

3. Improving the Distribution of Cement

The PTAP has identified two opportunities to reduce costs in the distribution of cement. One of these involves the change in the method of handling cement in the BPH operations from that in bags to that in bulk, where appropriate. The other involves the decentralization of the depots owned by cement manufacturers from locations primarily at the factory gate to locations at market centers where the demand is sufficiently high.

Two separate action plans are involved. The accomplishment of the first is to be the responsibility of the BPH, and involves the steps

necessary to convert road construction operations to accept bulk delivery of cement. The details involve the selection of pilot road-construction projects and are described in Chapter VI. The accomplishment of the second plan, which concerns the decentralization of factory depots, should be the responsibility of the Cement Industry Authority, but the BPH should encourage their efforts based on the results of the efforts to convert to bulk-cement handling.

4. Increasing the Utilization of Computers

The effective implementation of the action plans concerned with labor-intensive road construction and prolonging equipment service life will depend on the Task Force and on the BPH having easy access to high-speed electronic data processing. Intensive use of the BPH computer center, and outside centers as well, is to be made. Involved are training efforts, identification of appropriate activities in the BPH which can benefit, simplifying administrative procedures to secure use of the computer facilities, and publicity within the BPH.

The ultimate use of the pavement-evaluator program as a design tool in the BPH requires the collection and evaluation of data on road maintenance costs, and traffic and weather conditions over a period of time.

B. LINKAGES AMONG ACTION PLANS

In one of the topics, the construction of public roads and highways by labor-intensive technology, the goal is to help reduce unemployment by increasing the amount of labor used in the construction of roads and highways. In the topic concerned with prolonging service life of heavy construction equipment, the goal is to make it cheaper to use equipment in road construction, by getting more operating hours out of the investment, or, in other words, to make it less attractive to employ labor. In the topic concerned with moving cement in bulk, in other words getting rid of bags, capital machinery would be used, instead of labor for handling cement. Finally, in the topic concerned with computers, the goal is to replace methods of calculations employing prople by those employing capital machines. A natural question then arises. On the basis that the generation of jobs is the overall government policy, has the PTAP taken an inconsistent position with respect to the results of its work?

The PTAP believes the answer is "no" for a number of good reasons,

which involve distinguishing means from ends. These reason are:

- the employment of labor in road construction is seen as a means to an end rather than as an end in itself. The laborer by his toil should ultimately find himself enjoying a higher standard of living than before he began his toil. In effect, labor-intensive construction of roads should be likend to a "pump", which is capable of drawing from a pool of workers having a low standard of living and chanelling them through a pipe (i.e., the road) to a plateau of a higher standard of living. Such a concept avoids making a beast of burden out of man.
- the prolongation of equipment service life, in effect, may be considered as a means to employ labor. Equipment maintenance work is also labor-intensive, as would be to some extent the local manufacturer of spare parts. The difference is that in this case, the skills involved are at a much higher level for road construction, so that the workers engaged may consider their employment as an end rather than a means.
- assigning the educated and skilled technician to repetitive and monotonous tasks of the mind is not much different in principle to assigning a laborer to the repetitive manual tasks in road construction. The computer, properly used, provides the skilled technical person with opportunities to exercise judgment through choice among alternatives. Two benefits then arise. One is the higher level of motivation generated in the person himself, and the other is the identification of cost reduction opportunities once alternative can be identified.
- the time required for the repetitive tasks involved in the implementation of the labor-intensive and equipment service life action plans could be so long as to hinder the effectiveness of implementation. The computer is essential here.
- labor involved in handling bags of cement is hired purely on an ad-hoc basis without providing any opportunity for him to improve his lot. It appears to be a more sensible route to use capital to reduce financial costs through lowered cement prices, and thereby provide the displaced labor with more attractive job opportunities in road construction.

C. PROBABLE COST-REDUCTION EFFECTS

The scope of the PTAP efforts did not include attempts to quantify the extent of cost reductions that may result from the Action Plans. Such result should come from the implementation of the Action Plans. On the other hand, the PTAP can comment on the nature of the cost reduction, and on some of the factors involved.

1. Labor-Intensive Construction of Roads and Highways

The prospects are certain that appropriate use of labor-intensive methods in road and highway construction will reduce foreign-exchange costs and national economic costs. In some cases, financial costs may also be reduced, but more likely they may be increased. It appears that the prospects of reducing financial costs at the same time as the other costs depend largely on (a) the success of raising worker motivation to levels such that high productivity can be achieved, and (b) supporting workers by providing adequate tools, construction equipment, and amenities to sustain their motivation, to assure the completion of the project to the schedule, and to achieve the desired quality of the construction.

2. Prolonging Equipment Service Life

The prospects are certain that prolonging equipment service life will reduce foreign-exchange costs and national economic costs. It is probable that financial costs also may be reduced, although this could depend largely on the criteria adopted for deciding when useful service life had ended. One factor which requires attention in order to achieve reductions in the three costs simultaneouly is the total local manufacture of the spare-parts needs with acceptable levels of quality in the materials of fabrication and of precision in the dimensional specifications of the parts.

3. Improving Distribution of Cement

The prospects are that the financial costs of cement procurement for BPH projects will be reduced, but it is not clear whether or not foreign exchange and national economic costs will be reduced. Foreign exchange and national economic costs involve (a) the effect of increased demand for cement, which improved distribution of cement could generate, on the complex capital-intensive structure of the cement manufacturing industry, and (b) the fact that the production capability of this industry is currently substantially underutilized while the foreign-exchange expenditures have

already been committed based on full production.

4. Greater Utilization of Computers

The prospects are that all three costs may be reduced simultaneously. The facility to investigate design alternatives through the greater use of computers can serve to identify alternatives in which emphasis is put on the reduction of all three costs, or on any one of the three.

D. KEYS TO ACHIEVEMENT

Two steps, undertaken at the appropriate times, are worth remembering in the view of the PTAP. They are two steps which were followed during the PTAP work efforts. The first was the series of discussions held with the personnel in the BPH field offices. The second was the forum for free discussion provided during the three-day seminar. Both steps were attempts to produce results by talking with the people who would have to live with these results; to produce results by listening to these people as they talked with each other; to avoid an exclusive "ivory-tower" point of view in the PTAP results by knowing the "grass-roots" situation; and to insure that the actions now recommended will be useful by being responsive to the needs of the country.

Finally, the orientation represented by the two steps, in the view of the PTAP, assure that the recommendations will be implementable, because they reflect the views of the people in the field, who ultimately are the ones who do, who accomplish. The PTAP urges that similar actions be undertaken in the course of the implementation of the Action Plans.